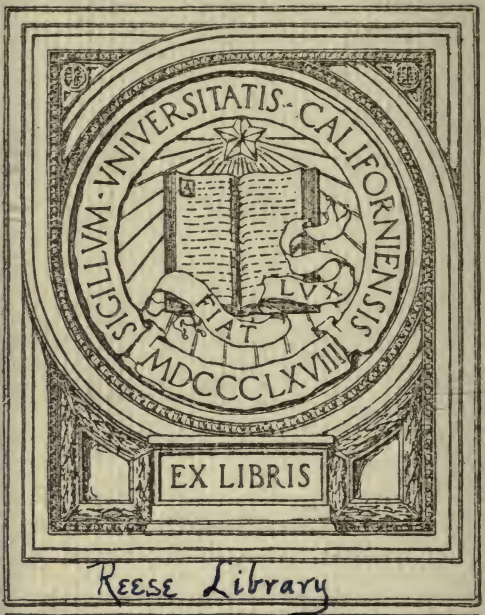

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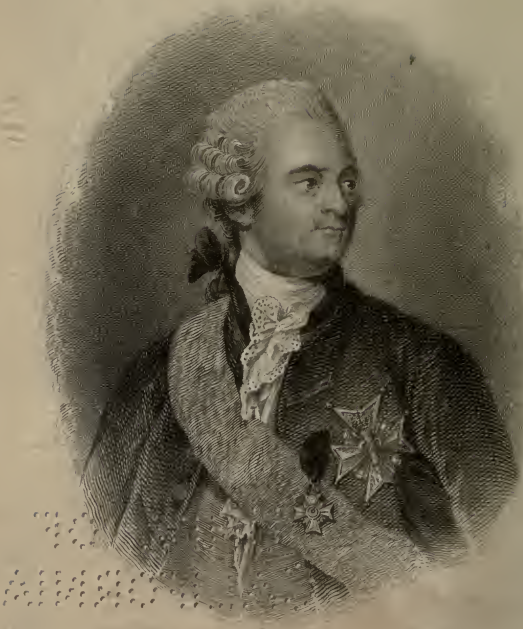

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VOL. XXVIII.

Entomology.

INTRODUCTION TO ENTOMOLOGY.

BY JAMES DUNCAN,

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MEMOIR

OF

SWAMMERDAM.

MEMOIR OF SWAMMERDAM.*

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EVERY one whose attention has been turned, however cursorily, to the history of physiology or of natural science, must be familiar with the name of John Swammerdam. He revealed so many important facts in the structure and functions of the lower animals and investigated their anatomy with such consummate skill, and scrupulous anxiety to discover the truth, that he is continually referred to as one of the highest authorities that can be cited. Indeed, he may be said to have laid the foundation of all true

* Our most diligent researches not having been successful in procuring a portrait of Swammerdam, although we have reason to believe that either a medal or an engraving exists, we have been compelled to deviate slightly from our usual practice, and present the memoir without that appropriate accompaniment. To preserve the uniformity of our plan, and still further to enrich our portrait gallery, we have prefixed a likeness of that distinguished entomologist, Baron de Geer, a sketch of whose life has accordingly been added. The latter is necessarily very brief, both on account of our space being exhausted, and because materials are not to be found for a detailed biography.

knowledge on these subjects; and, in particular, he is entitled to be regarded as the founder of the science of entomological anatomy. With a few bright exceptions—such as Goedart, Malpighi, and Redi—the cultivators of this department of natural history, before his time, contented themselves with repeating what had been said by the ancients, without being at all solicitous either to prove its accuracy, or extend it by the addition of new facts. With him observation began to supersede erudition; and the truth, which appears to have been so long almost unsuspected, that there were other and better sources of information, on natural objects, than the pages of Aristotle, or the ponderous compilations of the sixteenth century, was at length fully recognised and acted upon. The desire of prosecuting researches into insect organisation, became, with Swammerdam, an almost incontrollable passion. Professional views were sacrificed to it; his father's displeasure, expressed in no gentle terms, was incurred on account of it; and even when his health had completely given way, in consequence of incessant study and unremitting anxiety, we find him expressing his desire that he had but a year of uninterrupted light, that he might be enabled to complete his inquiries! Such assiduity, skilfully directed, could not fail to insure important results; and that such was their character, will appear when they come to be specially indicated.

His grandfather, James Theodore, was born at Swammerdam, a village on the Rhine, between Leyden and Woerden. Removing thence to Amster

dam, for the more convenient prosecution of his business, which was that of a timber merchant, he obtained the surname of Swammerdam from his native place, according to a practice which was very prevalent in Holland about that period. His only son, John James Swammerdam, the father of the subject of this memoir, was born at Amsterdam in the year 1606, and was brought up to the profession of an apothecary. This he seems to have exercised with sufficient success to enable him to devote a considerable portion, both of time and money, to the study of natural history, for which he had a strong partiality. This propensity led him to collect natural objects from all quarters, and the extensive commerce of the Dutch afforded great facilities, at that time, for accomplishing such a purpose. He amassed an extensive assortment of different animals, among which insects occupied the most prominent place, and likewise many plants and fossils, all which he arranged with great care, according to the crude notions which then prevailed respecting their differences or relations to each other. This collection, which likewise contained a great variety of miscellaneous curiosities, Chinese porcelain, articles of vertù, &c., became so celebrated, that strangers visiting the city were accustomed to resort to it, as one of the spectacles deserving of their attention. Such was the owner's estimate of its value, that he considered it worth sixty thousand florins.

The distinguished physiologist, of whom it is our purpose more particularly to speak, was the son of

this individual, and of Barentje Corver, daughter of John Jansz Corver, and was born at Amsterdam, on the 12th February, 1637.

He was from the first intended for one of the learned professions, and was early instructed in Latin and Greek with that view. As he grew up, his father formed the wish that he should study for the church, but from some cause or other he was himself disinclined to this step, and soon ceased to contemplate it. This probably arose from the high sense he entertained of the responsibility attached to the sacred office, and an apprehension that his talents and disposition might not fit him to discharge its duties in a manner commensurate with the idea he had formed of their importance. Under these circumstances, he obtained his father's consent to apply himself to medicine, a study well adapted to his inclinations, as attracting his attention to physical pursuits. Another strong incitement to such investigations was presented by the contents of his father's museum, which he was employed in arranging and keeping in a proper state of preservation. "This occupation," says the learned Boerhaave, to whom we are indebted for an interesting Life of Swammerdam, "led him to examine natural objects, even from his childhood, with the greatest attention. He soon ceased to be contented with what his father had purchased, and began to form a collection for himself. He devoted himself, in particular, to the examination of insects, pursued them in the fields, purchased them, exchanged other objects for them, and com-

pared the specimens he obtained with the accounts of the best authors, and afterwards arranged them in certain classes. When more advanced in years he applied himself most diligently to anatomy and medicine, all the while having his mind bent on the attainment of some important objects. He often spent both day and night in searching for and examining such insects as he could find, not only in his native district, but also in other parts of Holland. With this view he ransacked the air, the land, and the water; fields, meadows, pastures, corn-lands, downs, wastes, sand-hills; rivers, ponds, wells, lakes, seas, and their shores and banks; trees, plants, ruins, caves, uninhabited places, and even bog-houses, in order that he might make himself acquainted with the nests of insects, their food, manner of living, diseases, metamorphoses, and modes of propagation. And it may be affirmed, that in these particulars he discovered more facts and valuable information, even in his early youth, than all the known authors of preceding ages. However incredible this may appear, it is a fact that cannot be questioned, for the most competent judges have borne testimony to its truth."

He prosecuted his medical studies for a length of time in his native city, but afterwards repaired to Leyden, to avail himself of the advantages of its celebrated university. The surgical department was then under the direction of John Van Horne, and Francis Silvius de la Boe was professor of medicine, both of whom were men of celebrity.

There he continued for two years, labouring with such diligence and success, that he not only secured the high approbation of his instructors, but on the 11th October 1663, was admitted to the rank of a candidate of physic. At this time the study of human anatomy seems chiefly to have engaged his attention, and he made various trials to accomplish an object which has frequently been attempted since, namely, to preserve anatomical dissections in such a way that they might serve for demonstrations, and supersede the necessity of employing so many subjects. His zeal for anatomy led him to cultivate the friendship of every one eminent in that department, and they, in their turn, were not slow in appreciating his genius and enthusiasm. He formed a lasting friendship with Nicholas Steno, and was likewise intimate, for a time, with Rynier de Graaf, two of the most distinguished anatomists of that age.

About this time he appears to have first engaged in experiments on the respiratory system of frogs, a subject to which he often reverted, and which he illustrated with great diligence and success.

In 1664, he made a journey into France, and resided for some time in the house of Tanaquil Faber, at Saumur. While there, his attention was much occupied with the examination of the internal structure of insects, in which he made several discoveries. Of these, the most important was the valves of what Boerhaave calls the lymphatic vessels, which he detected by means of very slender tubes, which he had now acquired the art of employing, with great effect, for the

purpose of inflating the minute vessels. He also traced the different states of Dragon-flies, from the egg to the imago, from examples which he observed in the river Loire; and noticed most of the curious phenomena which attend their metamorphoses. He states, that the ovaries of these insects perfectly agree with those of fish, especially that of the herring, and consist, in like manner, of numerous eggs, which are of an oblong figure. When the vermicle, or young larva, has grown a little, four membranous buds or follicles, like flower-cups, are observed to spring out of the body near the end of the thorax; if opened at an early period, these are found to be mere bags, containing nothing but a watery ichor, but they soon become more matured, and the wings may be observed in them folded together. When full grown, all the varieties of colour and painting which distinguish the perfect insect, become transparent through the skin. The food of these larvae, he says, is soft mud, and the fine earthy substance in which they live. Although Swammerdam figures the singular mask of one of these creatures, he does so in an imperfect manner, and from his being unacquainted, as appears from the statement just made regarding their food, with their carnivorous nature, he had formed no accurate notion of its use. Neither does he appear to have detected the singular means employed to effect movement through the water, which is now known to be by the alternate absorption and ejection of that fluid from the abdomen, the resistance made by the stationary mass behind during the

latter operation, having the effect of urging the body forward. Notwithstanding these circumstances, most of his observations, and nearly all his figures, are extremely accurate, and were of great value at a period when many knew no more about the subject than Mouffet, who affirms that Dragon-flies are produced from rotten bulrushes! In contrasting the splendour, and what he calls the noble life of the Dragon-fly, with the larva from which it is produced, he says, that the latter, creeping and swimming slowly, is obliged to live *a life of misery;* an expression probably used in a different sense from that which would most obviously attach to it.

After leaving the abode of his hospitable friend at Saumur, Swammerdam visited Paris, where he took up his residence with Nicholas Steno. It was here that he first became acquainted with Melchesedec Thevenot, with whom he formed an intimate friendship, and whose patronage and encouragement, owing both to his attachment to physical pursuits, and the influence attached to his rank, afterwards proved of the highest advantage and comfort to him. In company with Steno, he paid a visit to this gentleman's country seat at Yssi, a few miles distant from the French capital, where he not only had an opportunity of prosecuting his researches into the history of natural objects, but of being introduced to the society of all the individuals of any eminence, whose habits and inclinations were at all congenial with his own. During the discussions which they were accustomed to hold on various subjects in art and

science, Swammerdam, for a time, was only a silent auditor; but his natural reserve by degrees wore off, and he not only took an active share in them, but delighted and surprised his fellow-guests by clearly demonstrating the structure and functions of the viscera of the lower animals, which had hitherto been supposed, owing to their minuteness and delicacy, to be beyond the reach of human scrutiny. His talents and disposition appear to have attached Thevenot to him warmly; and this feeling was as ardently returned, for Swammerdam declared shortly before his death, that he had never possessed so faithful and valuable a friend. Through Thevenot's good offices, he was introduced, and strongly recommended, to Conrad Van Beuningen of Amsterdam, at that time ambassador at the court of France, which opened up a new channel through which many benefits were conveyed to him after his return to his native city.

For three years subsequent to the period referred to, Swammerdam devoted the greater portion of his time to the study of physic and human anatomy. This he was induced to do, both from a desire to take a degree in medicine, and to enter upon the practice of it as a profession. The first fruit of his study were communicated to a society formed by the principal physicians of Amsterdam, for the cultivation of Medicine and Anatomy, and were subsequently published in their transactions under the superintendence of Casper Commelin. The subject was the Spinal Marrow. Of this he made a valuable

drawing, afterwards published by Blasius; and states the result of his inquiries in a letter to Thevenot, in the following particulars: 1. The Spinal Marrow consists entirely of fibres. 2. Those distinct fibres meet and terminate in some part of the brain. 3. Fibrous nerves issue from the fibres of the spinal marrow. 4. The pia mater is altogether extended into hollow sheaths. 5. All these things may be easily seen by suddenly placing the yet warm spinal marrow along with the vertebrae containing it in cold water, and breaking the vertebrae with great caution from the marrow, after having suffered both to remain in that situation during the space of a day and a night.

After composing an elaborate essay on Respiration as a thesis, he repaired to Leyden to take his degree. There he resumed his intimacy with the famous Van Horne, under whom he had formerly studied. Aware of his extraordinary skill in such matters, this Professor engaged him in a variety of experiments, and in forming anatomical preparations, for which he took care to supply him with abundance of materials; and with such enthusiasm did the young physician prosecute this congenial task, that he is said to have laboured both by night and day. It was on this occasion that he first injected the uterine vessels of a human subject with a ceraceous matter, a useful operation which he subsequently learned to perform with great accuracy and beauty. He now also began to practice a new and excellent method of preparing delicate viscera for demonstrations, namely

by blowing them up with air, after being properly evacuated and cleansed, an invention which developed and stiffened the parts as effectually as an injection of wax, while it did not render them opaque and confused, as that substance is liable to do.

He obtained his degree as Doctor of Physic on the 22d February, 1667, after a public defence of his thesis on Respiration. On this production he again concentrated his attention, and after thoroughly revising and enlarging it, speedily committed it to the press. It was published in the March following, and dedicated to his friend and patron Thevenot. Like all this author's works, it is distinguished for its originality, and most of the statements made, are the result of patient observation and experiment. But many of its views were too much opposed to generally received opinions, to be readily admitted; and the occasional introduction of extraneous matter, laid the work open to objection. Among other attempts made to refute its doctrines, there was one by John Baptist Van Lamsweerde, more remarkable for acrimony than talent, in a publication entitled, "An Expiration of Swammerdam's System of Respiration." But the work contained so many valuable observations and experiments, that it had no difficulty in withstanding these desultory, though spirited attacks, and ultimately took its place among those which have materially contributed to advance our knowledge of animal economy. No fewer than three editions have been printed at Leyden, of the re-

spective dates 1667, 1679, 1738, the two former in 8vo, the latter in 4to.

All his scientific pursuits, however, were suddenly interrupted in the course of this year by a severe attack of quartan ague, by which he was so much reduced, that he was obliged to refrain, for a time, from all mental and bodily exertion. When able to resume his labours, they were directed to a subject which had temporarily been superseded by other interests, but to which he always reverted with the ardour of a first affection, viz. the Anatomy of Insects. An impulse was given to his zeal by the interest which men of rank and science now began to manifest in his investigations; and many of them visited him to witness some of the arcana of nature revealed by his singular dexterity and penetration. Among the most eminent of his visitors, in regard to rank, was the Grand Duke of Tuscany, who had come to Holland, accompanied by Mr. Thevenot, partly with the design of examining whatever was most interesting in nature or art in that country. As this prince was a lover of natural history, Swammerdam was eager to gratify his curiosity, and made several dissections of insects in his presence; demonstrating, among other things, that the forms of the perfect Butterfly can be detected in the Caterpillar, and actually extricating all its parts, and rendering them distinctly recognisable,—an operation of sufficient delicacy to evince his consummate address, and the perfection of his instruments. So much struck was the Duke by his ingenuity, that he tried to prevail

on him to accompany him to Italy, by offering to purchase his museum for twelve thousand florins, and assign him a residence at his own court of Florence. But this generous proposal he did not hesitate to decline, both from an unwillingness to leave his native country, and submit to the restraint and change of habits which such a step would necessarily entail.

His prosecution of the study of insects was now almost incessant. When occasionally diverted from it for a short time by inevitable occurrences, he again returned to it with redoubled ardour, and a perseverance which seemed to know no relaxation. Of this we may judge from the fact, that in the year 1669—only two years after obtaining his degree, and notwithstanding the interruptions occasioned by his illness and numerous scientific avocations of a different nature—he published a General History of Insects; a work of considerable extent and remarkable labour.* During its preparation he neglected, in a great measure, his professional prospects, and incurred no small expense in collecting insects from all quarters of the world. Hitherto he had been entirely dependant on his father in pecuniary matters, and the latter now began to intimate his disapprobation of his manner of expending both his money and his time. He urged him to abandon pursuits which brought no remuneration, and betake himself

* Written in Dutch, and published at Utrecht in 4to. A French Translation appeared at the same place in 1682, and several Latin editions exist.

to the active and profitable duties of his profession. The zealous student himself saw the propriety of acting on this advice, and it seems to have been his design to do so; but he was so long in prevailing upon himself to forsake inquiries which afforded him so much gratification and delight, that his father's patience became quite exhausted, and he declared that he would afford him no farther supplies of money—a resolution which he soon carried into effect.

Thus thrown upon his own resources, Swammerdam had no alternative but to turn his medical skill to account; but the state of his health, which had been precarious ever since the illness mentioned above, and was still further impaired by unremitting study, proved inadequate to support the fatigue of such an employment. With a view to its restoration he retired to the country, and he had no sooner settled there than he relapsed into his former habits and studies. His generous friend Thevenot, upon becoming acquainted with his disagreement with his father, endeavoured to prevail on him to take up his residence in France, where he undertook to provide him with every thing requisite for carrying on his favourite pursuits; but, owing to the opposition made by his father, this invitation was not accepted. Still anxious to conciliate his incensed parent, upon returning to Amsterdam, Swammerdam employed himself for a time in making what was supposed to be a final survey of their joint collection, and drawing up a catalogue of the objects it contained, a laborious

task, which he afterwards regretted that he had undertaken.

During the years 1671 and 1672, his principal studies seem to have been more directly connected with his profession, for we find that he transmitted in that period to the Royal Society of London, a variety of plates representing the womb of a human subject, together with drawings of the spermatic vessels, tube of the womb, and ovaries. These were partly intended to illustrate his manner of making anatomical preparations, and filling both arteries and veins, even to their minutest ramifications, with a substance which preserved their primitive form and position. These were accompanied with a uterus prepared in the manner recommended. It was likewise his wish, by this communication, to vindicate his right, which had been disputed, to the discovery of certain facts regarding the spermatic vessels and the organs of generation. He was much engaged, also, at the period of which we now speak, in dissecting fishes, and making observations on their internal organs and their functions. The nature and properties of the pancreatic fluid, a subject which then excited much interest among physiologists, obtained a large share of his attention; and he made some important discoveries regarding the nature and cause of hernia. In 1673, he subjected to his powerful microscopes a variety of ferns in order to examine the fructification, which was then little understood. Two congenial spirits, Grew* and Malpighi,† entered upon this

* Anatomy of Plants, p. 200.

† Anatomia Plantarum, Pl. 51, Fig. 299.

inquiry nearly at the same time, and each of the three philosophers shewed that the dust on the lower surface of the leaves consists of an aggregation of small capsules, each surrounded by a jointed elastic ring, by the contraction and elasticity of which the capsules, when arrived at maturity, are opened with a spring, and the seeds (sporules) scattered to a distance; the whole exhibiting, Swammerdam remarks, the most wonderful construction that the mind of man can imagine, and so eminently displaying the contrivance, order, providence, and wisdom of the great Author of all things, that, perhaps, a more striking specimen of these His adorable perfections is not to be found in any other part of the visible creation. The size of the capsules, he states, is so minute that they are almost invisible to the naked eye, it being scarcely possible to make a dot on paper, with the finest pencil, of so small dimensions. In each of these capsules he reckoned about forty-one seeds, which are, of course, invisible to the unassisted eye; to examine them, he fixed some to a hair of his head, and, in comparison, the hair appeared like the mast of a first-rate man-of-war! He believes that there are more than sixty capsules in each little cluster; consequently, at a very low calculation, every one of the latter will contain 2460 seeds. The reflections with which our author concludes his remarks on this subject we shall here subjoin, both on account of their intrinsic value, and as an example of that strain of sentiment and devotional feeling which pervades his writings. "You may hence con-

ceive," (alluding to the minuteness of fern seeds, and the mechanism employed to disperse them,) " with what rapidity they may be wafted about by the wind, so as to account for these plants being found on the tops of the highest trees, and on walls, wherever they can find mould enough to take root in.

" The great obscurity of the human understanding is clearly proved by this observation, for, if it were not very dark indeed, how could it, during so many ages, deny that this plant had either seeds or flowers? insomuch that it was one of the first errors taught young people in books, as well as heard in conversation. We ought, therefore, to thank the Sun of divine grace, and true fountain of all useful knowledge, that we are at last so happy as to attain more just notions of this matter. Should not this mistake teach us modesty in our opinions and our judgment upon many other occasions, seeing upon this the most penetrating geniuses have all gone astray? If we are so liable to mistakes in regard to things that lie open to our inspection, what are we to say of our opinions of things that are invisible? How many idle notions are formed on such subjects! how many senseless conceits, with which, however, we sometimes suffer ourselves so far to be deluded that we make nothing of injuring, both in character and person, those who happen to be of a contrary opinion! It is therefore, absolutely necessary that we should always distrust ourselves and act with the greatest circumspection. In our present wretched condition, we are surrounded with ignorance on every side, and

have no other true knowledge than that of our own weakness and imperfections. Of ourselves we can do nothing, all we have we receive from the gracious hands of the Supreme Being, the munificent rewarder of good actions, of whose divine favour I wish you uninterrupted enjoyment."*

In the end of September, 1673, Swammerdam brought to a conclusion a work which had long occupied his attention, on a subject admirably adapted to his peculiar powers. No one so deeply interested as he had been from his infancy in the general history of insects, could fail to be particularly struck with the economy of bees, combining, as it does, much of what is most remarkable in other tribes of insects, with a great deal peculiar to itself. His efforts to become acquainted with their habits, and especially with their anatomical structure, have not been surpassed in labour and perseverance by any subsequent enquirer. For months together he was accustomed to commence his investigations at six o'clock in the morning, (when he could obtain sufficient light at that hour,) and continue them without interruption till twelve, seated all the time in the open air, with his head uncovered and exposed to the sun, the strongest light being necessary to enable him to use his magnifying glasses to the best advantage. About noon he was compelled to desist, as his eyes by that time began to fail from continual exposure to a bright light, and intent observation of minute objects through

* Book of Nature, Hill's edition, Part II. p. 153.

powerful glasses. The after part of the day, and usually no small portion of the night, were spent in registering his observations and writing out a detailed account of them, as well as in finishing his drawings. Such was his enthusiasm that he often used to wish that he had but one year of perpetual light and heat, to enable him to work without interruption. The whole of this laborious task, too, was executed while in a state of great bodily infirmity, and amid mental distractions arising from a cause to which we shall have immediate occasion to advert. Of the treatise resulting from these exertions, Boerhaave affirms, that all the ages from the commencement of natural history to his time, have produced nothing equal—nothing to compare with it. It is, certainly deserving of the highest commendation for indefatigable research, minute and accurate description, and elaborate delineations of internal organs. Indeed it may be said to have laid the foundation of an accurate and philosophical history of the Bee, and at the same time to have contributed largely to advance our knowledge of the structure of insects in general. When we consider how many interesting particulars Swammerdam brought to light, it will not appear surprising that several singular facts escaped his observation. The comparatively ample knowledge we now possess of the subject is due to the accumulated labours of many different individuals, and it might have been much more limited than it is had it not been for the happy expedient of employing glass hives, a thing which had not been thought of in Swam-

merdam's time. His investigations placed future enquirers on a vantage ground which they could not otherwise have attained, and, had it not been for the discoveries of Swammerdam, we might have wanted many of those made by Reaumur, Huber, and others.

So early as the year 1667 he had prepared and partly printed a treatise on the Ephemerus or Day-fly, as he calls it, but it was not published till 1675. It first appeared in Dutch under the title of *Ephemeri vita*. He states that his principal object in laying it before the public was to give us wretched mortals a lively image of the shortness of human life, and thereby induce us, by frequent admonitions, to aspire to a better state of being. It accordingly abounds with pious reflections and meditations to such a degree that the subject by which they are suggested is, in some instances, almost lost sight of. In most of the translations which have appeared these portions are omitted, as well as the numerous Dutch sentences in prose and verse which he has liberally introduced. He traces with great care and assiduity the whole changes of the insect from the egg to the perfect state, in which it lives only four or five hours. The internal anatomy is also elaborately described and figured, constituting by far the most valuable portion of the work. The following remarks occur towards the close:—"All of these insects die in the very short space of time just mentioned, nor do any of them,—which is a matter very worthy of observation,—die a natural death on land; all of them invariably go to the water again, after they have

gone through the second change of their skin. God, therefore, the Supreme Artist, has been pleased to assign this insect a short life that surpasses adoration.

"Who has so great a genius, or is so conversant in the art of writing, as to be able to describe with a due sense, the trouble, the misfortunes this creature is subject to during the short continuance of its flying life? For my part, I confess I am by no means able to execute this task, nor do I know whether nature ever produced a more innocent and simple little creature, which is, notwithstanding, destined to undergo so many miseries and horrible dangers.

"Besides that the life of the Ephemerus is short, nay, amazingly and incomprehensibly so, an infinite number of them are always destroyed in the birth, being devoured by fish. Nor does Clutius acquit any species of fish of this barbarity, except the perch and pike. Though the rest of the ephemeri have escaped this cruel danger, yet on land, when they are engaged in the great work of changing their skin, they are barbarously devoured by swallows and other birds. Nay, if they escape this danger, when they afterwards approach again to the surface of the water, and carelessly sport and play there with their wings and tails, they a second time become a prey to the fish, which drag them away to the dark bottom of the water, and devour them. If they fly higher into the air, another kind of torment attends them, for then they are persecuted with a different barbarity, by other kinds of birds, which tear their limbs asunder, and devour them. Though these insects

then are the most innocent, perhaps, of all others, they are more cruelly treated or used, than the most mischievous of wild beasts.

"As the ephemerus abounds with useful lessons and moral precepts, so it affords sufficient matter for various speculations. It is engendered, grows to its bigness, and then generates, lays eggs, casts its sperm, grows old, and dies in the space of five hours. This short space comprehends the morning, noon, and evening of its life."*

The species on which Swammerdam made his observations is the largest known, and is the *Ephemera longicauda* of Olivier (*Encyclop. Method. Art. Ephemera.*) In honour of the individual who made us so accurately acquainted with its history, Latreille subsequently named it *E. Swammerdiana.* It is not a native of this country, but occurs in the larger rivers of Holland, Germany, and France.

About the same time, he investigated in a similar manner the history and anatomy of what he names the asilus or gad-fly, but which is a dipterous species of the modern genus Stratiomys, or chamæleon fly. His attention had been probably attracted to this insect, by the singular breathing apparatus of the larva, which consists of an anal orifice surrounded by a circle of diverging rays of beautifully feathered plumes. This singular structure, and the elegant appearance of the respiratory appendage, has caused it to be often described and delineated in modern

*Book of Nature, Hill's ed. where will be found a synopsis of the *Vita Ephemeri.*

works, but Swammerdam's figure greatly surpasses all that have subsequently appeared (See *Biblia Naturæ*, pl. 39.) It was figured before his time, both by Goedart and Aldrovandus, the former of whom called it the chamæleon, from having kept an individual alive for nine months without food; the latter names it the water intestine. Both were unacquainted with its metamorphosis, and nearly all its most remarkable peculiarities; Swammerdam's account leaves little to be desired. He was so much struck with the beauty of its parts, and their exquisite adaptation to the functions they perform, that he frequently breaks out in lamentations of his own inadequacy to examine them aright, and in adoration of the power and goodness which they so signally manifest. "O God, thy works infinitely surpass the reach of our feeble understandings; all that we actually know of them, or ever can know, is but a faint and lifeless shadow of thy adorable perfections. The brightest understandings fail in the contemplation of them, and are obliged to confess, that all this boasted penetration is but short sightedness, when employed in fathoming the depth of that power, goodness, and wisdom, it has pleased thee to exert in the lowest part of thy creation.

"The transformation from a worm to a fly, observable in this insect, presents us with a real miracle, and may justly be considered, as a laying down of old worn-out parts, and an acquisition of new perfect ones instead of them; in fine, as a total change of an old to a new, and of an imperfect to a

perfect body, infinitely surpassing the utmost stretch of human understanding. As for my part, I dare boldly affirm, that the incomprehensible greatness of the deity manifests itself in these mysterious operations in a particular manner, and affords us an opportunity of examining, as it were, with our senses, the divine nature."*

Long before the period when these and other valuable investigations of a similar kind were undertaken, a notable change had taken place in Swammerdam's mind, which led him to regard such pursuits in a very different light from what had been customary to him. He had always been of a devotional frame of mind, and this feeling was gradually deepened by observing the wonderful instances of design, power, and goodness, which his studies so abundantly supplied. Hence his anxiety to direct the attention of the reader, on all fitting occasions, to the Almighty Author of all the wonders his penetration enabled him to reveal, and to awaken those sentiments of devout adoration which they are so well fitted to inspire. But an event happened, apparently in the year 1672, which corrupted the source from which these feelings flowed, diverted them into a wrong channel, and ultimately brought his mind into a state of the most deplorable fanaticism. The immediate cause of this was the perusal of the works of Antoinette de la Porte Bourignon, a wild enthusiast, who was then using every effort to propagate her doctrines. She was a

* Book of Nat. II. 51.

native of Lisle in Flanders, a member of an opulent family, from which she fled in order to avoid a marriage which they were desirous for her to contract. Her turbulent disposition, in connection with her objectionable tenets, so disturbed the community wherever she took up her residence, that the civil authorities had usually to interfere, and compel her to change her abode. Her doctrines nearly correspond to those of the Mystics, and are explained in a work entitled the "Light of the World," the leading principle of which is, that the Christian religion consists neither in knowledge nor practice, but in a certain internal feeling and divine impulse, which arises immediately from communion with the Deity.*

* One of the most influential of Bourignon's followers was a person named De Cordt, owner of a portion of the island of Holstein, who, at his death, made her his heir. She kept her wealth, however, to herself, under the pretence that she could find none worthy of her bounty! Although there is little doubt that her intellect was disordered, she was certainly possessed of considerable talent. She could write French, Dutch, and German, almost with equal facility, and her religious compositions were so numerous as to afford employment for a printing press kept in her own house. She died at Franeker in 1680. Her disciples, who assumed the name of Bourignonists, became more numerous after her decease; and one of the most celebrated of them, a Cartesian named Peter Poiret, attempted to reduce her works to a system, which was published at Amsterdam in 1686, under the title of "L'Œconomie Divine, où Systeme Universel." Her opinions, at one time, excited a good deal of discussion in Scotland, and notwithstanding their extravagance, found not a few supporters. *See Mosheim's Eccl. Hist.* V. p. 514, *&c.*

These opinions Swammerdam appears to have adopted in their utmost extent, and their effect on his melancholic temperament was such as to produce a completely morbid state of mind. The studies in which he had taken greatest delight, now began to appear odious to him. It was with the utmost difficulty that he could allow himself to finish his favourite work on Bees, and no sooner was it completed than he put it into the hands of another, without giving himself the least concern what might become of it. His inclination urged him strongly to continue his pursuits, but he now thought them incompatible with his duty to the Creator, as he alone, and not his creatures, was worthy of engrossing all his love and regard. All worldly interests, accordingly, were soon despised and abandoned, and he devoted himself wholly to the performance of the duties of religion, according to the erroneous notion he had formed of them. Every step he took was by the advice and authority of Antonia Bourignon, and she took care not to endanger the influence she had acquired over him, by allowing him to resume his former occupations, or engage in the ordinary business of life. His condition was rendered more deplorable and hopeless, by a return of his former complaint, quartan ague, in greater severity than ever, occasioning such a prostration both of mental and bodily powers that he was for a time unfit for any kind of exertion. He now resolved to withdraw entirely from the world, and spend the remainder of his days in solitary meditation. Before taking this

step, however, sufficient prudence still remained to lead him to consider what means he possessed of supporting himself in his retirement. His father could not be expected to afford facilities for carrying such a mistaken scheme into execution, and the only disposable property of any value he himself possessed, was his museum. That, accordingly, he resolved to sell, and he applied first to Thevenot, to make his intentions public, and to endeavour to procure a purchaser. This was readily undertaken by his friend, but notwithstanding his utmost exertions he was unable to get it disposed of. In this disappointment, he made a similar application to Nicholas Steno, who was now settled at the Court of Florence, where he had become a convert to the Catholic religion, and had been raised to a bishopric—a dignity likely to have the effect, if it was not conferred with the design, of making him stedfast in his new faith. Swammerdam thought that through his representations, the Grand Duke might be induced to renew the offer he had formerly made for the collection. The bishop of Titiopolis, in reply to his communication, urged him very strongly to come to Florence with his collection, assuring him that the Duke would willingly give the price formerly offered, as well as provide for his comfort otherwise; and, with the presumptuous zeal of a new convert, he took advantage of the opportunity to press him with every argument to follow his own example, and conform to the church of Rome. The implied condition that Swammerdam was to accompany his museum to Tuscany, if pur-

chased by the Duke—a step which he never could bring his mind to—immediately put an end to any chance of disposing of it in that quarter; and he wrote an indignant reprimand to his venal friend for venturing, in reference to his religious profession, to make a proposal to him which would at any time have been considered offensive, but which, in the present state of his sentiments, he regarded with unqualified abhorrence. While measures were in progress for the sale of his museum, he occasionally employed himself—notwithstanding his conviction of the sinfulness of allowing any secular pursuits, even including those of science, which may be said to be the best and purest, to distract the mind from uninterrupted meditation on the Supreme Good, and the concerns of a future life—in further arranging and improving its contents, especially with a view to render the many delicate preparations it contained as durable as possible, and thus increase their value in the event of a sale.

Swammerdam's intercourse with Bourignon had hitherto been confined to epistolary correspondence, but he now conceived it essential to his happiness that he should have a personal interview with her, and for this purpose he repaired to Sleswick in Holstein, where she then resided. He staid for some time in her house, and became ere long one of her favourite adherents. An opportunity soon occurred to afford a proof of her confidence in him, and the sincerity of his attachment. The Lutheran divines of Holstein, taking alarm at the pernicious principles

and proceedings of this enthusiast, were devising measures to have her expelled from the province, and on becoming aware of their intention, she wished to take shelter in the king of Denmark's dominions. Swammerdam, and another disciple, were appointed to visit the Danish court, to ask permission to make this change of residence—a commission which he readily undertook. He accordingly set out for Copenhagen, on the 25th March 1676; but was wholly unsuccessful in his object. He returned to Sleswick to give a report of his reception, and after a short residence there, went back to Amsterdam.

His prospects in that city had not improved in his absence; his father, whose resentment had been somewhat mitigated of late, was irrecoverably alienated from him by his recent imprudence. His sister Joanna, too, who had resided with his father since his wife's death, and often interceded with him on her brother's behalf, had just been married; and his father having resolved to live henceforth with his son-in-law, Swammerdam found himself at last deprived of a home. In this exigency, two hundred florins a-year allowed him by his father, was all that he had to depend upon, and this being inadequate to defray his necessary expenses, he was obliged to think of some plan for relieving his necessities. A gentleman of rank, John Ort of Nieuwenrode, Breukele, &c., who had been long on terms of intimate friendship with Swammerdam, had often entertained him at his country-seat, and even proposed that he should take up his residence there altogether, that

he might be able to pursue his scientific enquiries without molestation. He now intimated to this gentleman that it would be convenient for him to accept of this offer; and his mortification was not slight at receiving a direct refusal. Whether Ort had been insincere in his original offer; whether circumstances had so changed as to render Swammerdam's presence inconvenient, or that the latter's peculiar habits, and extravagant religious notions, might be thought likely to make him not a very desirable inmate, it is useless to enquire: instances of similar treatment, from mere caprice and want of feeling, are too common to render any other explanation requisite.

In the midst of these perplexities our author's father died, an event which relieved him from any immediate inconvenience arising from the insensibility of his reputed friends; it even held out to him the agreeable prospect of a competency to live according to his inclinations, without the annoyance of any professional drudgery, to which he always entertained a strong dislike. But, when the museum came to be disposed of and his father's property divided, these prospects were by no means realised. His sister claimed more than was rightly her due, and took the chief management of the sale, an exercise of authority to which Swammerdam submitted for the sake of peace, and that he might sooner enjoy the retirement and repose on which his heart was set. But even this surrender of his just rights was far from exempting him from annoyance; and the vexations attending

the family strife that ensued, together with the anxiety he continually felt about his spiritual state, and his almost unintermitted devotional exercises, again brought on a severe disorder of that description called a double tertian ague. During this long-continued illness, he was mostly confined to bed, and unfit for any exertion; even when it was so far abated that air and exercise became desirable, he could not be prevailed on to leave his bed-chamber. In order to avoid the importunity of his friends on this subject, he persisted for a long time in maintaining an obstinate silence. In this moody and hypochondriacal state of mind, when any one attempted to draw his attention to the investigations which he formerly delighted in, he manifested great dissatisfaction, and even seemed as if he would feel relief by getting completely rid of the objects which he had taken such pains to collect and preserve. A final offer of them was made to Thevenot, that he might dispose of them in France, accompanied with an intimation, that, if he should succeed, Swammerdam would accept of his invitation to come and live with him, provided he were allowed to do so retired and unknown. Thevenot, however, was unsuccessful; and, as he now despaired of finding a purchaser for the entire collection, he determined to sell it by auction in separate lots, for such sums as might be offered. The sale was advertised to take place in the month of May, 1680.

With whatever indifference Swammerdam might now regard his collection, he was not destined to witness its dispersion. His disorder returned with

greater virulence than ever, accompanied with symptoms which he could not misinterpret. A slow and continued fever was gradually drying up the sources of life; his countenance became cadaverous, his legs, feet, and belly swollen, and his whole body was racked with continual pains. On becoming acquainted with his condition, Thevenot sent him the Jesuits' bark, then supposed to be of great efficacy in curing fevers; Swammerdam desired him also to send some specific against the dropsy, if he knew of any such. Finding himself grow gradually worse, he ceased entirely to speak of worldly concerns, and was unremitting in his preparations for the great change that was rapidly approaching. It took place on the 17th February, 1680.

On the 25th January of the same year, when he found himself in such a condition as to leave no hopes of recovery, he had made his will, by which he bequeathed to Thevenot, the friend so often mentioned in the course of this sketch, all his original manuscripts relating to the history of bees, butterflies, &c. along with fifty-two plates which had been engraved from his drawings. He ordered, besides, a collection of valuable papers on scientific subjects, then deposited in the house of Herman Wingendorp, at Leyden, to be delivered to the same person within a year after his death. Madam Volckers, wife of a physician named Daniel de Hoest, was made his heiress; this lady was also appointed his executrix, jointly with Christopher Van Weyland, but the latter dying soon after, the trust devolved entirely into her hands.

The papers just mentioned had been entrusted to Wingendorp in order that he might translate them into Latin. Swammerdam is said to have had but little facility in the use of that language, although it was the usual medium of communication among learned men at that period; it is certain that he wrote all his works in Dutch, and afterwards employed others to translate them, that they might not labour under the disadvantage of being in a local and unpopular tongue. The translator, in this instance, being needy and unprincipled, tried to make a property of the manuscripts in his possession, and refused to deliver them up to the executors. Upon this, a tedious law-suit ensued, and it was not till May, 1682 that the legatee had them placed at his disposal. It was his purpose to have them published immediately in Dutch, but probably finding that they required revisal, he caused them to be sent to France. He appears to have attempted some alterations and improvements, a task for which he was probably indifferently qualified, but his death took place before he had them ready for publication. After Thevenot's decease, they were purchased by Jubert, painter to the King of France, whose heirs afterwards sold them, for fifty French crowns, to a distinguished anatomist, Joseph du Verney. This individual for a long time disregarded them, but the anatomy of the articulated animals happening to come more into repute, he proposed to turn them to account in a work on insects under his own name, but of which they were designed to form the principal materials. On hearing of this

the investigations relating to insects, which compose the greater portion of the work, there is a lengthened account of the snail, (*Helix*,) explaining its anatomy, mode of propagation, &c., a treatise on the generation of the frog, on the anatomy of the cuttle-fish, &c.

The manner in which Swammerdam treats of the arrangement of insects into classes, is, as might be expected, not a little defective. But he was certainly the first that assumed metamorphosis as the basis of a natural system, and in so doing, merits high approbation. He referred all to four classes of metamorphosis, which, translated into the modern language of entomology, may be expressed as follows:

1. *No metamorphosis.* The animal changes its skin, but preserves its primitive form; as in *Aranea*, *Pulex*, *Myriapodes*. In short the *Aptera* of Linnæus.
2. *Metamorphosis. a. Incomplete.* Animal active during its whole life: at first without wings; acquires rudiments of them in the nymph, and they become complete in the imago. *Neuroptera*, *Orthoptera*, *Hemiptera*.
   ——— *b. Complete.* Animal immoveable in the nymph state; but possessed of limbs. *Hymenoptera*, *Coleoptera*, *Lepidoptera*.
   ——— *c. Coarctate.* Animal without limbs, and incapable of motion in the nymph state. *Diptera*.

The science of insect anatomy, as well as of some other tribes of animals related to insects, may almost

be said to have originated with Swammerdam. His intimate acquaintance with human anatomy, which had made considerable progress before his time, prepared him to enter upon the enquiry in the most intelligent manner; and the sagacity, penetration and zeal with which he pursued it, are not a little remarkable. In the latter quality especially, he scarcely ever had an equal: no difficulties could deter, no disappointment discourage, and scarcely any degree of labour exhaust him. His enquiries were frequently carried on for a length of time together, with little interruption, both by night and day, without allowing himself the requisite time either for taking food or natural rest. When the subject occupied his mind, it did so almost to the entire exclusion of every thing else. His profession was neglected, his father's displeasure disregarded, his health sacrificed. This exclusive engrossment was certainly in him in some degree of a morbid nature. His constitution and temperament strongly predisposed him to that kind of enthusiasm which is allied to a species of mania. By sedentary habits, and the prevention of that wholesome play of the faculties produced by an alternation of pursuits, he aggravated the disorders to which he was naturally liable, and brought on a state of dejection and hypochondriasis, which cast a shade over a large portion of his life. To this cause, also, ought to be ascribed, in no small degree, the mistaken views he adopted regarding religious duty; his notion that it was incompatible with the ordinary

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business of life; and numerous other errors, from which his good sense and general intelligence, if left to themselves, would have sufficed to preserve him.

After his death, his museum was offered for sale for five thousand florins; but no one appearing to give even that sum, so far below its real value, it was disposed of in small lots. It was thus completely dispersed, and lost for ever to men of science. The anatomical preparations were very numerous, and he had carefully preserved every thing relating to his entomological and other investigations, that he might have them to appeal to as unquestionable vouchers of the truth of his statements. He had collected about three thousand different species of insects; many of the kinds occurring in his neighbourhood he had preserved in their various states, having been accustomed to hatch the eggs artificially, and watch the progressive changes of the larvae that spring from them. His instruments, microscopes, &c., shared the same fate with the objects on which they had been employed. Boerhaave deposited the manuscripts and drawings which came into his possession, and furnished him with materials for the *Biblia Naturæ* and an account of its author's life, in the public library of the University of Leyden, that they might remain as a monument to the talents and zeal of his distinguished countryman.

Considerable curiosity must naturally be felt to become acquainted with the means adopted by this lynx-eyed anatomist to effect those beautiful discoveries which distinguish his name so highly above

all his predecessors in the same field of labour; and this feeling we are in some measure enabled to gratify by the care of his biographer, Boerhaave, whose account is so satisfactory, that we cannot do better than nearly translate his own words. For the dissection of very minute objects, he had a small brass table, ingeniously constructed by an artist of Amsterdam, to which were attached two moveable brass arms. The upper part of these arms was so planned as to admit of a vertical motion, so that the operator could adjust their height to answer his purposes; one of them was designed to hold the object under examination, the other, the glasses through which it was to be viewed. These glasses were, of course, in great variety, as well as the manner in which they were fitted up into microscopes, and it was always a matter of great anxiety with Swammerdam to obtain them of the best possible substance and workmanship. It was his practice first to view the object under examination through a glass of comparatively small power, and to apply stronger ones gradually as he was becoming more familiar with its forms and appearance, a practice by which every observation was made subservient to the next, and the deceptive tendencies of different lights in a great measure guarded against. His skill and patience in constructing cutting instruments were remarkable, and it is, in a great degree, to their ingenious forms, and extreme delicacy, that much of his success is to be ascribed. His scissors were remarkably fine and sharp-pointed, and this was a favourite instrument with him, as he found it

separate a membrane equably, without the laceration or disorder which a single edge, however sharp, is apt to produce in delicate substances. These, as well as his variously formed knives, lancets, styles, &c., were so small and fine, that he could not sharpen them without the aid of a microscope. He employed to very great advantage, and with a dexterity entirely his own, slender glass tubes, sometimes no thicker than a bristle, and of a similar shape, being wide at the one end and tapering to a point at the other, to blow up the smallest vessels discovered by the microscope, or to inject them with some coloured fluid, by which their course, convolutions, and implications could be traced.

The insects designed for dissection were killed by immersion in water, spirits of wine, or of turpentine, and allowed to remain in some one or other of these substances for some time, which prevented putridity, rendered the parts firmer and stronger, and the dissections consequently easier. When he had laid open with fine scissors the body of the insect, he carefully noted the relative situation of the parts before proceeding farther; he then extracted the viscera in a very leisurely and cautious manner, separating and washing away with very fine camel's-hair pencils the fat which surrounds them. After extraction he frequently floated the delicate viscera in water, and, by shaking them gently, separated the different parts from each other, and thus obtained a better opportunity of examining them. In this way he was very successful in getting a distinct view of the air-vessels

especially, which he could separate from all the other parts, and exhibit in a manner that excited the surprise and admiration of all who had an opportunity of observing them. For the purpose of cleansing thoroughly the internal parts, he was accustomed to inject water into them by means of a small syringe, after which they were filled with air and dried; in this way they could be preserved for examination at any future time. Not only was he thus successful in investigating the internal organs of recently killed insects, but he could examine them in specimens which had been preserved for years in balsam and spirits of various kinds. This afforded him the advantage of dissecting foreign species, many of which being of much greater size than such as occur in Europe, present all the parts in a more conspicuous manner. He could preserve the nerves in such a perfect state, that they retained their flexibility for a long time, and looked as if newly extracted from the living subject. Insects of a soft and fleshy consistency, he preserved in a variety of ways. Sometimes he punctured them in various places with a needle, and expressed all the fluids and moisture in their bodies through the pores thus made; he then filled them with air by means of slender glass tubes, dried them in the shade, and lastly anointed them with oil of spike, in which a little resin had been dissolved, by which means they retained their proper forms for a long while. With caterpillars he devised the plan which has often been followed since, namely, making an incision near the tail, and gently squeezing out all the

humours and greater part of the viscera, and then filling the empty skin with wax or some other substance, so as to preserve its primitive form. The fat of insects he found to be perfectly soluble in spirits of turpentine—a discovery of the greatest importance to his enquiries, because when melted, and afterwards dried, this substance forms a coating over the viscera, completely obstructing the view of them; but the application of the spirit effectually removes it. He often spent *whole days* in cleansing the fatty matter from a single caterpillar, that he might obtain a clear view of its internal organization. His plan for stripping off the skin of caterpillars about to undergo their metamorphosis was ingenious. He allowed them to drop by their threads into scalding water, and suddenly withdrew them, in consequence of which the skin came off with great ease: he then immersed them in distilled vinegar and spirits of wine, mixed in equal proportions, which consolidated all the parts. He could thus remove the integuments without injury to the contents, and could shew the chrysalis enclosed within the caterpillar, and the butterfly within the chrysalis. He at last carried his skill to such perfection, that, according to Boerhaave, he could change the caterpillar to a chrysalis at his pleasure, and could as he pleased forward, stop, and regulate its motions.

MEMOIR OF DE GEER.

Swammerdam, as has just been seen, was chiefly employed in examining the internal anatomy of insects; the high reputation of the Baron De Geer, of whose life we are now to give a brief sketch, rests principally on his admirable description and delineation of their external structure. Deeply embued with a love for investigating the forms and habits of these animals, and possessing powers of observation of the first order, he succeeded in discovering many important facts in their economy, which he has detailed in a remarkably clear and interesting manner. A pupil of Linnæus, and an ardent admirer of the philosophical French naturalist Reaumur, he combined the systematic regularity of the one, with the experimental skill and patient observation of the other. His works accordingly have been always looked upon as a store-house of important facts, lucid descriptions, and enlightened observations, which have tended perhaps as much as any other publication that could be mentioned, to increase our knowledge of the class of animals of which they treat.

Charles de Geer, Baron of Leutsta, Marshal of the Court of Sweden, Knight of the Polar Star, and Com-

mander of the Order of Vasa, was born in the year 1720. When about four years of age, he left Sweden, his native country, and accompanied his parents to Holland, where he continued to reside till his eighteenth year. His family originally belonged to that country, but had left it and established themselves in Sweden in the time of Gustavus Adolphus. The head of the family at that period was Louis de Geer, who acquired great wealth and reputation by the improvements he effected in manufactures and the mechanical arts. He introduced new methods of casting iron and brass, established founderies for canon, and manufactories of fire-arms, bringing workmen from Leige and other places to conduct them on the most approved principles, and to instruct the native artists. These foreign artizans were so numerous as to form a colony in the canton of Dannemora, where their descendants long continued to reside. That the wealth and influence of this ancestor of our naturalist were extensive, may be judged of from the fact, that, in the reign of Christinus, when the country was threatened by a foreign enemy, he equipped a considerable fleet for protecting the commerce of the coasts, exclusively from his own resources. His patriotism and philanthropy were rewarded by his name being enrolled among the nobles of the country.

When in Holland young De Geer is said to have acquired a taste for Natural History by observing the proceedings of some silk-worms, which had been given him to rear as an amusement. This predilection was confirmed by his conversations with the

celebrated Muschenbrock, with whom he was on terms of intimacy. His studies were commenced at Utrecht, but he afterwards removed to Upsal, where he had the advantage of enjoying the combined instructions of Linnæus, Celsius, and Klengenstiern. Under such masters his progress in physical science was rapid; and it was not long before opportunities occurred to afford proofs of his proficiency.

By the death of an uncle, he came into possession, at an early age, of one of the largest fortunes in Sweden. The extensive iron mines of Dannemora became his property; and he expended large sums in improving the mode of working them. Every scheme tending to promote the prosperity of his country, and the spiritual and temporal welfare of its inhabitants, found in him a zealous and intelligent patron. His wealth he liberally shared with the poor, and devoted no small part of his income to the repairing of churches, and the founding of hospitals and schools But these philanthropic objects did not divert his attention from the pursuits of science; on the contrary, he continued to cultivate his favourite branch of Natural History with the utmost zeal and assiduity. As a member of the Academy of Stockholm, he regularly attended its meetings, and supplied many interesting memoirs in different departments of knowledge. His observations on insects were now beginning to accumulate, and he read a few papers on the subject to the society, which are inserted in the early volumes of their Transactions. But these observations soon became so extensive and import-

ant as to demand a separate work for their due development and preservation; and this accordingly he prepared to lay before the public.

The first volume appeared in 1752, under the title of *Mémoirs pour servir à l' Histoire Naturelle des Insectes:* dedicated to the Queen. It is a 4to. volume, written in French, and containing 37 plates. The principal subjects of which it treats are, the history of various kinds of caterpillars, such as leaf-rollers, those found in galls, the kinds producing butterflies and moths, &c. Many of the latter are figured and described in their perfect state. Those who have purchased the work, which cannot now be easily obtained, at least in this country, may have experienced how much more difficult it is to procure the first volume than any of the succeeding ones, without probably being aware of the cause. It is well known, that at the time of which we now speak, as well as for a long period subsequent to it, the study of the lower animals, although eagerly prosecuted by a few individuals in different countries, was entirely disregarded or even held in contempt by most people, including not a few even of those who arrogated the title of men of science. Owing principally to this circumstance, the appearance of De Geer's first volume did not excite so much interest and attention as his own estimation of the subject of it had prepared him to expect; and allowing, for a moment, the feeling of disappointment to get the better of his prudence, he committed a great part of the impression to the flames. But this feeling was very transient, and he resumed his labours

with as great zeal as before. A considerable period, however, elapsed (nearly nineteen years) before a second volume appeared, and four others were subsequently published at short intervals. It is said that he sent a copy of each of them as a present to all those who had purchased the first. The seventh and last volume was not laid before the public till after the author's death, an event which took place on 8th March 1778. He had been for many years previously afflicted with gout, and it was that disorder which terminated his useful and honourable life. The numerous and valuable objects in natural history which he had collected, were presented by his widow to the Academy of Stockholm, and the members have placed a marble bust of their benefactor in that part of their museum where they are preserved.

His great work contains descriptions of upwards of 1500 species of insects, a general history of their manners and metamorphoses, and carefully executed engravings, often highly magnified, of their different states, and not unfrequently of their separate parts both external and internal. These plates amount to 238, and being of a quarto size, they necessarily afford space for the representation of an immense number of objects. The contents of the first volume have been already mentioned. The second opens with an introductory sketch of insects in general; continues the history of moths and butterflies, and includes that of bees, ephemeri, and ants. The third is devoted to the description of Aphides, Cimices, Notonectae, grasshoppers, crickets, dragon-flies, &c.

The fourth and fifth are wholly occupied with the Coleoptera, and contain an account of numerous larvæ pertaining to that order which were previously unknown. The sixth volume embraces the Diptera. The seventh is of a more miscellaneous description, and besides some insects properly so called, contains a notice of crabs, spiders, scorpions, myriapodes, and some other animals which at that period were always ranked with insects. It is from this part of his work that we have copied the beautiful portrait prefixed to the present volume; but although a posthumous publication, it is unfortunately unaccompanied with any account of the author's life.

All naturalists competent to form an enlightened opinion on the subject, unite in admitting that these memoirs are entitled to the very highest praise to which a work of this description can lay claim. Both nature and fortune conspired to fit De Geer for successfully prosecuting the study to which he was so ardently attached. The natural endowments of his mind were of no ordinary kind, and the best education which the times could afford had the usual effect of strengthening and improving them, and adapting them to observe and discriminate with readiness and accuracy. His time was at his own disposal, and his ample fortune gave him the immediate command of every thing that could facilitate his investigations. Such a concurrence of favourable circumstances does not often happen, and it is not often, therefore, that we can expect to be favoured with works of such value. They were combined, however in the case

of a cotemporary of De Geer's, the celebrated Reaumur; and, as it was the works of the latter which had the greatest influence in stimulating the zeal of the Swedish naturalist for the study, it is natural to institute some comparison between them. As the result of this comparison, it may be briefly affirmed, that Reaumur shows greater skill in making his observations, more felicity in planning experiments, and a readier power of exciting interest in the narration of them; but De Geer is less prolix in detailing facts, more precise, and infinitely more methodical. The absence of the latter quality in the French philosopher has rendered it impossible, in many instances, to determine the objects to which his observations refer. As a disciple of Linnæus, De Geer could not fail to be early impressed with the value of system, and that which he framed for the arrangement of insects claims a brief notice. In a tabular form, it will stand thus:—

- Insecta.
  - Alata.
    - Gymnoptera.
      1. Lepidoptera.
      2. Elinguia, (*Ephemeræ*, &c.)
      3. Neuroptera, (*Dragon-flies*, &c.)
      4. Hymenoptera.
      5. Siphonata, (*Aphides* and *Cicada*.)
    - Vaginata.
      6. Dermaptera, (*Bugs* and *Water-Bugs*.)
      7. Hemiptera, (*Cockroaches* and *Grasshoppers*.)
      8. Coleoptera.
    - Diptera.
      9. Halterata, (*Diptera of Linn.*)
      10. Proboscidea, (*Coccus*.)

Insecta.
- Aptera.
  - Saltatoria. 11. Suctoria, (*Pulex.*)
  - Gressoria.
    12. Aucenata, (*Lepisma, Podura, Pediculus*, &c.)
    13. Atrachelia, (*Spiders* and *Crabs.*)
    14. Crustacea, (*Isopoda, Myriopoda.*)

This arrangement, which has been explained in a separate work by Retzius,* is, in several respects, inferior to that of Linnæus, the improved editions of whose *Systema Naturæ* had previously appeared. Yet in one particular it was an improvement, namely by the insulation of the Orthoptera, which Linnæus had confounded with the Hemiptera. The parts of the mouth are taken into consideration in De Geer's system, and in this respect it may be said to be intermediate between that of Linnæus and Fabricius. In many instances it must be allowed to be highly natural and worthy of emanating from such a distinguished entomologist, and there can be little doubt that it would have enjoyed more consideration than has fallen to its lot, if every thing of this nature, at the time when it appeared, had not been eclipsed by the culminating star of Linnæus.

* *Car. lib. Bar. de Geer genera et species Insectorum, &c.* 8vo. *Lipsiæ*, 1783.

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INTRODUCTION TO ENTOMOLOGY.

"On reconnaîtra partout l'empreinte de cette INTELLIGENCE ADORABLE, qui crayonna, de la même main, l'Homme et la Mouche."—BONNET, *Contemp. de la Nature.*

INSECTS form a portion of that extensive department of animated nature known by the name of Articulated animals. They are so called on account of being composed of joints or segments, a structure which renders their bodies pliant, and thus compensates for one of the inconveniences that would otherwise arise from the want of a vertebral column. Some ancient authors designated them by the term *annulata —quasi in annulos secta*—and they are frequently described in modern works as annulose animals. They are now referred to five great classes: 1. *Annelides,* such as leeches and earthworms; 2. *Crustacea,* such as lobsters and crabs; 3. *Arachnides,* such as spiders and scorpions; 4. *Myriapodes,* consisting of juli and scolopendræ; 5. *Insecta,* containing beetles, butterflies, &c.

The term *insect* has likewise been suggested by the structural peculiarity just alluded to, the transverse divisions causing the body to appear intersected or cut into; and the Latin word *insectum,* from

which it is derived, is exactly synonymous with the Greek one ἔντομα, from which we obtain the principal component part of the term *Entomology*.*

Both words therefore are sufficiently descriptive of the whole articulated races, and, in fact, when originally applied, were designed to embrace them all. In the more limited and precise sense in which it is now used, the word insect is applied to such animals only as present the following characters:—no internal skeleton; a nervous system composed of ganglions; an imperfect circulating system; respiration by means of tracheæ communicating with the air by stigmata; oviparous, the sexes distinct; body covered by a coriaceous or membranous integument, and divided into three distinct sections, viz. the head, provided with two antennæ; the thorax, with six articulated legs; and the abdomen, usually having the sexual organs at the extremity; and, finally, not presenting these parts in full developement till after having passed through (with very few exceptions,) several successive changes called *metamorphoses*.†

These negative and positive characters, derived both from external and internal parts, will be found distinctive, and completely exclusive of all the other

* Scaliger affirms that the word *insecta* was applied to these animals, not on account of their appearance, but because they might be cut into or asunder without destroying life. Pliny adheres to the common acceptation, which is, in all probability, the right one.

† Lacordaire's *Introd. à l'Ent.* I. 3; Audouin's *Résumé d'Entomologie.*

allied races with which insects have any chance of being confounded. To render this the more obvious, a brief notice may be taken of a few of the more prominent peculiarities presented by each of the other articulated classes, when compared with that in question. The *Myriapodes* make by far the nearest approach to them in essential properties, the internal structure being almost identical, while many of the external parts are similar: thus there are generally two composite eyes, two antennæ, and oral organs similar to those of masticating insects. The differences, however, are sufficiently striking, and consist of the numerous segments, without any division of the body into thorax and abdomen; in the number of feet, always exceeding six, and sometimes amounting to two hundred; and in the body acquiring with age an increase in the number of the component segments. The *Arachnides* generally have the head soldered to the thorax, and many of them seem to have no other incisure than that which separates the thorax from the abdomen; no antennæ nor composite eyes; more than six feet, and the generative organs placed, with very few exceptions, under the belly before the middle. In that section of them named Pulmonaria, after the air has been admitted by stigmata, it is received by a kind of sacs, analogous to the lungs of vertebrate animals, and the circulation in consequence is pretty complete; in the other division, Trachiana, the respiratory organs resemble those of insects, and the circulation is therefore less perfect. The *Crustacea*, agreeing in very many points with

Insecta, differ from them, in regard to external parts, in having a greater number of legs, the head soldered to the trunk, four antennæ, (in the great majority) and the composite eyes usually raised on moveable footstalks; and, in reference to internal structure, in possessing a complete circulation, and branchiae for respiration analogous to those of fishes. The only connection which the *Annelides* have with the preceding classes, arises from their annulated structure, the want of an internal skeleton, a similar nervous system, and in being oviparous; in all other respects they are widely removed from them. Their blood is red, like that of the vertebrata; the head is scarcely distinct, and there are no antennæ properly so called; none of them possess proper feet, and the majority are hermaphrodite.

Besides these distinctions, special to each individual class of the articulata, they all have this common difference from insecta, that they are destitute of wings, and do not undergo metamorphosis.* Their growth is gradual and insensible, during which many of them change their skins, but they preserve, with few exceptions, the same form they had at birth. Insects, on the contrary, pass through a variety of changes, during which they assume such dissimilar forms, that it is often impossible to recognise the same individual at different periods of its existence. The

* This assertion, however, must not in one instance be made absolute, for in regard to the Crustacea, a certain kind of metamorphosis may be assumed as having been recently demonstrated.

different stages are four in number, that of *egg, larva, pupa,* and *imago* or perfect insect.

All insects are, strictly speaking, oviparous. The few instances which might be supposed to prove that this is not universally the case, are more apparent than real deviations from the general law. Certain two-winged flies, cocci, ground-bugs, (*Cimicidæ,*) and aphides, give birth to larvæ; the forest-flies of the singular genus Hippobosca, and its near allies, enter the world in the pupa state. The larvæ in question, however, are not developed in a uterus by means of a placenta, like the embryos of true viviparous animals, but come from eggs hatched within the body of the mother; while the forest-flies, besides being hatched in the same manner, likewise pass the penultimate stage of their life, which is probably of very short duration, in the matrix of the parent. These two tribes, therefore, may be said to be ovoviviparous.

The eggs of insects do not often fall under our observation, on account of their small size, and being carefully concealed, by a variety of ingenious devices, that they may not fall a prey to birds and other enemies. Their most common situation, at least with such as produce herbivorous larvæ, is on the leaves designed to serve these larvæ as food; at other times they are placed in fissures of wood, made by an instrument specially designed for the purpose, and not unfrequently in fruits and grain; many are deposited in the earth, and not a few in water. They are placed either singly or in groups. Their defence

against cold and other atmospheric influences, consists of a coating of varnish, hair or down stripped from the body of the insect, leaves drawn carefully around them, or a covering of frothy matter. The female coccus converts her whole body into a covering for her eggs, enveloping them closely on every side; the great water-beetle (*Hydrophilus piceus*) deposits them in a bag, and carries them at the extremity of her abdomen, like the spider commonly observed under stones, (*Lycosa saccata.*) In form, colour, sculpture, &c., they vary infinitely in different tribes; some of them we have already described and figured, and it will be more satisfactory to notice the peculiarities of others in connection with the particular history of the insects that produce them, than to introduce here a lengthened general account of objects so dissimilar.

The number of eggs laid by different species, is as various as their properties. At one extremity of the scale they approach the vertebrated races, at the other they surpass all other animals in the creation. Thus a pretty large fly, which may frequently be observed resting on the stems of trees, (*Mesembrina meridiana*) lays only two eggs, while the female white ant lays probably not fewer than forty or fifty millions in a year, extruding them, when in the act, at the rate of sixty in a minute! Of such as are intermediate between these two extremes, the numbers are, of course, very various; but it may be affirmed that insects are in general much less prolific than fishes. Among the latter, a million occurs occasionally, and half that

amount may be said to be not uncommon. *Aleyrodes proletella*, a small hemipteron, is the only recorded insect, except the white ant, that makes any approach to the last named number, and even it does not exceed 200,000. An insect resembling an ant, possibly a Mutilla, is said to have laid 80,000 in one day. The queen bee may occasionally produce 50,000 eggs in a season, but the ordinary amount does not exceed 5000 or 6000. The female wasp sometimes lays about 30,000, but commonly not more than 2000 or 3000; cocci between 2000 and 4000; some moths a thousand or upwards; but in far the greater number of instances, even in regard to the more prolific kinds, the number may be expressed by three figures; and, in the vast majority of cases, the eggs certainly do not amount to a hundred. Generally speaking, carnivorous species are least prolific, and herbivorous ones most so; an ordination in harmony with the supply of food, which is limited and precarious in the former case, constant and almost inexhaustible in the latter.

Our acquaintance with the composition both of the exterior and interior parts of insects' eggs, is far from being complete. The integument generally offers but little resistance, being a mere membrane, not unfrequently so transparent as to reveal the changes that take place within; at other times it is hard, dense, and opaque. The former is the case with eggs deposited in the earth, (as takes place in many Coleoptera, Orthoptera, and Hemiptera,) the moisture and protection of which are probably indispensable for preventing the

evaporation of the fluids; the latter is exemplified by such as are exposed (as they often are among the Lepidoptera) to the action of the elements. No calcarious ingredient enters into the composition of the envelope, as may be proved by the application of an acid which produces no effervescence. Under the outer envelope there is another very thin pellicle, enclosing the fluid within, the whole of which must be regarded as the yolk. The latter is a thick granulated mass, variable in colour, and, as far as it has been examined, found to consist of albumen, some animal glue, a yellow oil, sulphate and phosphate of natron. With the earlier stages of embryo life, we are still imperfectly acquainted; but when it has continued for some time, several organs can be detected in the process of development. Suckow first observed the intestinal canal, displaying even the constrictions which separate the œsophagus and intestine from the stomach. Air-vessels are likewise visible, but their function is as yet dormant, as they have no communication with the atmosphere. The dorsal vessel is also developed, and Swammerdam observed its distinct pulsations. The commencement of the nervous system appears in two scarcely perceptible filaments, which gradually approximate, till they unite at different points forming incipient ganglia. The head, mandibles, and anal horn, (when the latter exists,) are, in general, the parts most distinctly marked in embryos.

It is a very anomalous fact, that the eggs of insects often augment in bulk after they are laid. The rigidity

of the shell renders this impossible in the generality of vertebral animals, and it is not observed to happen in other cases where there is no such obstacle, except indeed it be in fishes, which are said to present a similar peculiarity. In such instances it cannot be supposed that the eggs grow, in the proper sense of that word; they must be considered merely as increasing in volume by the distention of the flexible envelope accommodating itself to the larva, which increases somewhat in size as it assimilates the liquid filling the interior. M. P. Huber found the eggs of ants when ready to be hatched nearly twice the size of those newly laid. Reaumur, however, seems to be of opinion that there is a positive absorption from without of the surrounding fluids, and that in the case of saw-flies and gall-flies, the vegetable juices are imbibed from the leaves on which they are fixed, in a manner which does not easily admit of explanation.

As the period of hatching depends on temperature, it varies with the state of the atmosphere, and the greater or less degree of influence with which that is permitted to act owing to the consistency of the egg-cover. The natural heat too is sometimes modified by the substances in which the eggs are placed, as when the nidus consists of dung, for example. In the heat of summer, the time that elapses between the deposition of the egg and exclusion of the larva is not of long duration; but it is too variable to admit of any general period being mentioned. In perhaps the majority of cases, it varies from one to ten days;

often it extends to a month, and occasionally to several months. When the eggs of such species as have several broods in the course of the season, and are speedily hatched to admit of such frequent propagation, happen to be laid in the close of autumn, they continue unchanged throughout the winter, and disclose their larvæ in the spring. Notwithstanding their generally soft consistency, insects' eggs can bear great extremes of temperature without destroying their vitality. There has been no deficiency in the ordinary number of insects last summer, although many of them would be exposed, in the egg state, to the unusual rigours of the preceding winter. Spallanzani placed some with impunity in an artificial mixture, which reduced the thermometer to 22° below zero; and experiments of the same nature have frequently been made since, with a similar result. The same skilful observer found, that a temperature of 90° did not materially injure the eggs of the silk-worm, but a higher degree destroyed the fertility of many, and none could resist a heat of 144°. The situation selected by the parent insect, is often exposed to the highest degree of natural heat that can be obtained. The Melasomas of America lay their eggs in sandy places where the thermometer has been found to rise above 70° (R.) during the heat of the day, and those of Nyctelia have been observed in similar places, where it was impossible to hold the hand for a few seconds on account of the heat.

Want of air is more speedily fatal to them than

either heat or cold, none having ever been found productive after remaining for a time in the vacuum of an air-pump.

When the whole of the fluid in the interior of the egg has been assimilated, and the young larva matured, it emerges either by rupturing the envelope, gnawing it asunder, or pushing open a kind of moveable lid at the end, constructed apparently for the express purpose of facilitating its exit.

Larva. Insects as often present themselves to our notice in this stage of their existence as in their perfect state, and not unfrequently attract our attention by their depredations on the produce of our fields and gardens. In consequence of being so familiarly known, they are distinguished by a variety of popular names. Grubs are the larvæ of coleoptera; maggots, mawks, and gentles, those of diptera; and caterpillars the larvæ of butterflies, moths and saw-flies: the larvæ of most of the other races not differing materially in appearance from the matured insects, do not require a distinctive appellation in ordinary language. Lepidopterous larvæ, or the caterpillars of butterflies and moths, we have already described at considerable length;* those of beetles also have been occasionally noticed,† and the particular history of the other kinds will be afterwards given under their respective orders and families. The pre-

* See Naturalist's Library—Entomology, British Butterflies.

† See Naturalist's Library—Entomology, Beetles.

sent remarks are of a more general nature, and applicable to the whole.

The majority of larvæ have a vermiform appearance, the body being long, narrow, and inclining to cylindric. Such as present this aspect are the kinds which differ most conspicuously from the perfect insect; the others differ only in parts which are not influential over the general appearance. An obvious division of larvæ, therefore, is into such as are wholly unlike the perfect insect, and such as bear a greater or less resemblance to it. They are all destitute of wings, and have the common character of being unfitted to propagate the species.

Some attempts have been made to classify larvæ in a manner similar to that followed with perfect insects. These have not, however, been attended with much success, both on account of the inherent difficulties of the subject, and our comparatively imperfect acquaintance with insects in that condition. Mr. MacLeay was the first who endeavoured to divide them into groups, to which he assigned names suggested by the analogy which they presented to other articulated animals. Thus, for example, he names *Chilognathiform,* such larvæ as offer certain analogical forms reminding us of scolopendræ; *Chilopodiform,* those resembling juli; and those resembling lepisma he terms *Thysanouriform.* This author applied his system to the larvæ of coleoptera only; Kirby and Spence adopted the idea and extended it to the other orders; and it has been more or less

acted upon by other authors. But in the present state of our knowledge, a classification of this nature appears premature, there not being a sufficiency of facts and observations on which it can be satisfactorily founded.

The orders in which the larvæ have a strong resemblance to the perfect insect, are Hemiptera, Orthoptera, and certain genera of Neuroptera; in all the others, with a few exceptions, there is no resemblance between the two states.

In every instance insects may be considered as composed of thirteen segments, including the head, but in matured examples these are often merged in each other, owing to the disproportionate development of certain parts. In larvæ the mode of life, movements, &c. being more uniform, an enlargement of one segment is seldom made at the expense of another, and we accordingly find the normal number distinctly marked. They are most regular and uniform, however, in such as bear least resemblance to the winged insects they produce, although they can be traced without difficulty in nearly all other instances. The three segments immediately behind the head correspond respectively to the prothorax, mesothorax and metathorax of the perfect insect, and bear the three pair of legs (when these happen to exist,) which have been called the true legs, because they are persistent, to distinguish them from the abdominal or prolegs which are caducous and peculiar to the larvæ. The curious structure of the latter has

been already explained, and further details will be given hereafter.

Whenever the larvæ are provided with oral organs formed for suction, the same conformation obtains in the prefect insect; but suctorial species are often produced from masticating larvæ. In the former case the nature of the food scarcely varies in the whole course of the animal's existence; in the latter it must necessarily be quite dissimilar. The various parts of the mouth, as well as other appendages of the head, are analogous in form and function to those that exist in the imago. An upper and under lip, mandibles and maxillæ, and from two to six palpi can be distinguished; antennæ and eyes (the latter generally of the simple construction,) are likewise present, in far the greater number of cases. The mandibles vary in form and consistency according to the nature of the substances upon which they are designed to act: in many carnivorous tribes they are long and curved; and in Dytiscus, Hemerobius and Myrmelion, they have another and a singular function superadded to their ordinary uses: they are perforated throughout their whole length, and thus form a tube through which the animal sucks the juices of the prey which it has secured by their means. Among many Diptera, the mandibles serve as instruments of motion; the larva fixing its posterior part to the plane of position, and then stretching its body in advance, seizes some point of support with its jaws, and by their aid easily drags the body

forwards. Maxillæ are sometimes wanting, (as among many dipterous larvæ,) but when present they are placed immediately under the upper jaws, and are more or less subservient to mastication. They are generally without the lobes which distinguish the corresponding parts of the imago, but there is, for the most part, a palpiform process, analogous to the internal maxillary palpus, or what is called galea in the orthoptera. Palpi exist in all larvæ save dipterous and hymenopterous ones, but they are often short and inconspicuous. The maxillary palpi are sometimes four in number, at other times only one is attached to each maxilla; the labial palpi are always limited to two. Their shapes are conical, setaceous or filiform; the joints variable in number, and not unfrequently branched. The upper lip presents nothing peculiar, but the under lip, in the tribe of dragon-flies, (*Libellulidae,*) assumes a very singular form, as will be seen when we come to specify the peculiarities of the order Neuroptera. In connection with the under lip, there is an instrument peculiar to some larvæ, namely, a spinneret—a small conical tube through which the silken threads are drawn, which are so indispensable to the economy of a large proportion of them. The antennæ are far from presenting that variety of design and beauty of structure which render them, not unfrequently, very ornamental appendages to insects in a state of maturity. They are often entirely wanting, (as in the maggots of many two-winged flies, bees, &c.) and frequently so minute, that even when they do exist, they cannot easily be

detected. Not rarely, however, they are pretty conspicuous, consisting of four or five joints in the majority of beetles, and of two or three in caterpillars. The joints are frequently contractile within each other, so that the antennæ can be protruded or withdrawn at the pleasure of the animal.

The head of larvæ is usually of a harder substance than the rest of the body, and in that case is commonly of a triangular or orbicular shape; but its covering among the diptera is soft and membranous, from which results the singular anomaly that it is capable of dilatation and contraction, and therefore of assuming any form the insect may desire. The remarkable spines that arm the heads of many foreign caterpillars have been already mentioned.*

On the various and numerous appendages of larvæ, whether serving for respiration, ornament, or defence, it is unnecessary to enlarge in this place, as it would only be anticipating what can be more appropriately introduced hereafter. Their anatomy will be considered conjointly with that of the perfect insects. But there are other interesting features in their history, to which it will be most convenient to advert in this place, namely, their growth, moulting, and preparations for entering upon the pupal or penultimate state.

The growth of larvæ is in most cases rapid. The whole structure of the animal, indeed, indicates provision for its speedy increase in size. The instru-

* See Naturalist's Library — Entomology, British Butterflies.

ments of munducation are strong and efficient; the digestive organs greatly developed, and the skin periodically thrown off to remove any impediment to the distention of the body. The consumption of food is necessarily great, in some cases exceeding that of any other animals, regard being had to their respective size. In fact, many of the kinds which consume the foliage of plants eat with little intermission; and, in some instances, they continue to feed both by night and day. The growth of the larvæ of flesh-flies (*Sarcophaga*) is unusually rapid, some of them having been found to become 200 times heavier in twenty-four hours. When it has attained its full growth, the caterpillar of the goat moth is sometimes 72,000 times heavier than when newly hatched. The experiments of Count Dandalo on the silk-worm, make it appear that when just hatched, this caterpillar is a line in length, and a hundred weigh about a grain; after the first moulting, the length of each is four lines, and a hundred weigh fifteen grains; after second moulting, length 6 lines, weight 94 grains; after third moulting, length 12, weight 400; after fourth moulting, length 20, weight 1628; after fifth moulting, the length of each is upwards of three inches, and a hundred weigh about 9500 grains.

The number of these moultings or changes of skin varies greatly in different insects, but it is always alike in the same species. The intervening periods likewise vary, being dependent on the length of life allotted to the larvæ. In the silk worm, as has just been seen, the moultings are five, and all these occur

within the space of thirty days. From five they extend to nine or ten, the latter number having been observed in the tiger moth, (*Chelonia caja.*) But the great majority of insects do not undergo this operation oftener than three or four times. The caterpillars of butterflies are usually limited to the former of these numbers, those of moths to the latter, but among moths many other exceptions occur besides the one mentioned above. The proximate cause, as already intimated, of this moulting, is the more rapid expansion of the body than of the skin, which, in consequence, soon exceeds the capacity of its envelope: the latter, it is true, admits of a certain degree of distention, but a few fixed points on its surface, as well as the rigidity of the part enclosing the head necessary to give support to the masticating organs, prevent it keeping pace with the growth of the body. The larva ceases to eat when the change is approaching, and, during this temporary suspension of its ordinary employment, the fat lying immediately beneath the outer skin is absorbed, a circumstance which greatly hastens the crisis by abstracting the moisture from the skin and shrivelling it, while, at the same time, it tends still further to dilate the internal parts. The colours, being dependent in a great measure on the freshness and moisture of the skin, also become dull and confused. The only motions made by the larvæ are occasional contortions and undulatory movements of the segments, which ultimately produce a complete separation between the exterior skin and the new

one beneath it. By continuing these, a rent is soon made, usually on the back behind the head, through which the creature forces its way, while the exuviæ are held back by the hinder extremity, which the larva was careful previously to attach to some object with this very design. The divestment is so complete and adroitly managed that the cast integument may easily be mistaken for a living larva, as it exhibits all the parts which characterised it, apparently without having undergone any material change. This process of renovation, however, is not wholly confined to the external parts; several of the viscera also are said to cast a fine skin, and even the aëriferous tubes, though so numerous and delicate, undergo the same process, and the rejected membranes are gradually expelled from the body through the stigmata.

Several tribes of larvæ do not change their skin at all, not even when about to become pupæ. These belong chiefly to the order Diptera, whose membranous contractile heads and expansible skin removes the necessity of subjecting them to the same law as those differently circumstanced in these respects.

The last change of skin, which occurs just before the assumption of the pupa state, is essentially similar to the others, but it is preceded, in many instances, by certain precautions and preparations, with a view to security and comfort during the quiescent condition about to ensue. The larva leaves its wonted haunts, and seeks some retreat where it will be less exposed to the weather and its numerous living enemies; the crevices of trees and walls, the shelter of dead leaves,

moss, or stones, the eaves of out-houses, and similar places, are industriously sought after, and many bury themselves a considerable depth in the earth. But the selection of a suitable retreat is far from being their only care, at least with a great many; other precautions are resorted to, many of which afford examples of singular ingenuity and persevering labour. This is particularly the case with the caterpillars of butterflies and moths. The former either suspend their chrysalides horizontally by the tail and a silken band round the middle, or by the tail alone, allowing the body to hang perpendicularly. The manœuvres by which the caterpillar manages to place the band round its body are extremely curious and interesting, and have, therefore, been particularly described in the volume of this series already mentioned and to which we must again refer. The cocoons of moths have likewise been described in a similar volume devoted to their history; and that tribe of insects affords the best examples of this species of fabrication. Most of the Hymenoptera likewise form silken cocoons; a few Coleopterous and Dipterous genera, (Hypera, Donacia, Mycetophila,) and the Neuropterous groups Hemerobius and Myrmeleon; the latter differing from nearly all the rest in having the apparatus for spinning their threads at the extremity of the abdomen, instead of in the head. Cocoons of silk are often strengthened by the addition of other materials, such as particles of earth, portions of leaves, fragments of wood, &c.; and occasionally cocoons are formed altogether of these substances held together by

a glutinous secretion without the assistance of threads. Saw-flies, and some other Hymenopterous tribes, construct a double cocoon, the outer one not united to the interior, but inclosing it as the shell of a nut does its kernel. Many larvæ dwell in habitations which they form with much skill and labour, to defend their tender bodies, and these likewise serve as a ready and efficient protection for the pupa. Such are the cases of the May-flies (*Phryganeæ*) which are common in slow flowing streams, and curious on account of the materials with which they are covered; the mantles of many leaf-rolling caterpillars, and the portable tents constructed by others. Dipterous larvæ are frequently converted into pupæ within their own skin, which changes its form and becomes of a more rigid texture for the purpose of affording it more effectual protection. The change to a pupa does not always take place immediately after the preliminary arrangements are completed, although the contrary is the general rule; a period of inactivity often ensues; and some caterpillars remain unaltered within their cocoons for months together.

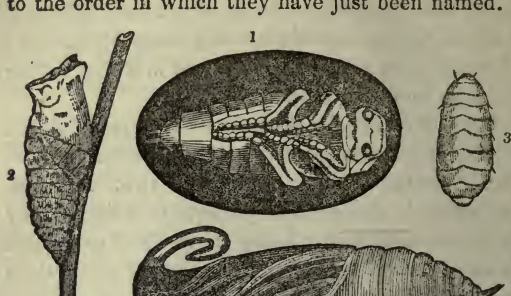
Pupa. This is the most general term applied to insects in the third stage of their existence, that, namely, which intervenes between the larva and imago. It was suggested by their appearance, which resembles that of a child wrapped up in swaddling clothes, all the parts being closely folded down, and enclosed in a general envelope. It is, therefore, very applicable to the majority of them, as they are completely dormant and inert, incapable either of moving

or of taking food. But although this is the general condition of pupa, it is by no means universally so; many scarcely differ in appearance from their larvæ and are equally capable of moving about, and equally voracious. This affords a convenient means of separating them into two great divisions, the one comprehending such as resemble their larvæ, the other those which bear no resemblance to their larvæ. To the first of these divisions belong all those pupæ which Linnæus called *complete*, viz. the Orthoptera, Hemiptera, (with some exceptions,) and certain tribes among the Neuroptera. The principal perceptible difference between these pupæ and the perfect insects consists in the wings not being fully developed; but these organs approach gradually to a state of greater maturity with the age of the pupa, although without breaking through the case that contains them. The general form of the body, and the organization of the mouth, are similar in both states, the other differences besides the one indicated, when such exist, being confined to the legs or certain other parts of structure which are of utility to the pupa when it differs in its economy, as sometimes happens, from the imago. Thus the pupa of Cicada has the forelegs greatly thickened and adapted for digging, because in that stage of its life it lives beneath the ground; after undergoing its final change it frequents trees, and the fossorial legs, being no longer useful, disappear. The respective states of larvæ and pupa in the tribes in question being not indicated by any marked character, it is often

very difficult to say at what precise point of time the transition from the one to the other takes place; and in such species as are perfectly apterous, (such as Cimex Lectularius and many Phasmidæ,) a like difficulty may be experienced in distinguishing the pupa from the imago.

The second division comprises the pupæ of all the orders not enumerated above, and constitutes, therefore, by far the most extensive of the two. Although they agree in the general property of being wholly unlike the larvæ, and in being incapable of eating and walking, they yet offer not unimportant distinctions among themselves in several particulars. Some have all the limbs encased in separate membranous envelopes, and therefore lie free, although closely adpressed to the body; others are covered with a hard skin or horny case, on which the different parts can be traced by their forming projecting lines; while in others the integument is opaque and uniform, concealing every thing within it. To the first of these belong the entire orders Coleoptera and Hymenoptera, as well as certain tribes among the Neuroptera and Diptera. These were called by Linnæus *incomplete* pupæ, by Lamark *mumiæ coarctatæ*, and by Burmeister *pupæ exaratæ*. The second form the *obtected* pupæ of Linnæus (*pupæ larvatæ*, Burm.) and comprehend all those of the order Lepidoptera, which are usually known by the term *chrysalis*. The third subdivision includes the larger proportion of the order Diptera, which were the *pupæ coarctatæ* of Linn., the case being nothing more than the dried skin of

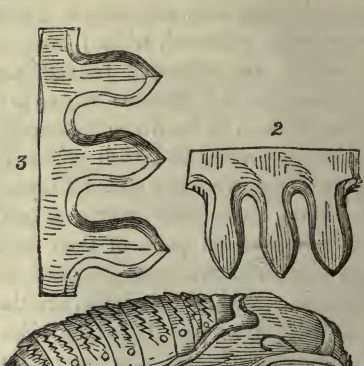
the larvæ. The following figures afford examples of these different kinds of pupæ, the numerals referring to the order in which they have just been named.



On examining the interior of a pupa immediately or shortly after it is formed, it is found to consist almost entirely of a milky fluid, which soon, however, acquires the consistency of pulp, when the members of the future insect can be detected. They are not long in enlarging by the absorption of the ambient matter, and when they acquire their full size, they completely fill, in most instances, the interior of the pupa-case. The integument, as above intimated, varies greatly in its consistency. In the Lepidoptera it acquires its rigidity from a viscous fluid, which oozes out from the region of the thorax, and spreads over the whole surface, forming a hard and varnished shell. The superficies is for the most part naked. In some cases, however, it is tufted with hairs, (as in *Orgyia pudibunda, Leucoma Salicis;*) occasionally

it bears insulated spines; and not unfrequently it is tubercular. The colour of the kinds that are little exposed, from their situation, to the action of light, is generally yellowish-white; many of those, however, which are concealed beneath the earth, are light-brown; most of those belonging to the Lepidoptera are greenish or brown, sometimes speckled, and occasionally ornamented with golden spots, on which account they were first called Chrysalides and Aureliæ. Many pupæ have strong angular points projecting from various parts of their bodies, and sometimes these are processes designed for a particular function. Such, for example, are the clavate appendages which project from the sides of the thorax in the pupæ of gnats, and some other dipterous species which live in the water. The dorsal segments of many are armed with sharp serratures looking towards the anus, which serve an important purpose in their economy, for it is by their means the pupa works its way to the surface of the ground, when the perfect insect is about to be disclosed. When the segments are curved, the convex side, by means of these spines (called *adminicula* by Kirby), finds a *point d' appui* higher up than it occupied formerly, and when it has attained this elevation, another curvature of the abdomen enables it to gain another step. In this way they have no difficulty in rising to the surface merely by wriggling the abdomen from side to side. This structure is well exemplified in the large pupa of the goat moth, a highly magnified view of whose serrated dorsal ridges

presents the appearance delineated in the adjoining wood-cut.



The pupa having made so much nearer an approach to the perfect form than the larva, exhibits some indication of the principal divisions of the body which afterwards become so strongly marked. A slight constriction frequently points out the boundaries of the head, thorax, and abdomen. Regarding the exterior sheath as the case (*theca*) of the pupa, Kirby and Spence have assigned a nomenclature to its principal parts: the anterior division enclosing the head, is called the Head-case (*cephalo-theca*); next to this is the Trunk-case (*cyto-theca*); and lastly the Abdomen-case (*gastro-theca*). The coverings of all the other parts receive names from the Greek words for these parts compounded with theca; thus the

eye-case is called Ophthalmotheca, the antennæ-cases, Cerathecæ, &c.

The length of time insects pass in this stage of their existence varies from a few days to nearly two years. Each species, however, has in general a definite period assigned it from which there is no material deviation, unless under very peculiar circumstances. Perhaps the most general duration is from two to four weeks, but, even in the same species, this depends upon the season of the year, for a pupa which would disclose the perfect insect in a few weeks during the summer, will frequently lie dormant throughout the entire winter. Unless a provision of this kind obtained, it is obvious that many insects would infallibly perish from being brought into existence at a time when it is impossible to find the means of maintaining life. The immediate cause of this prolongation of their quiescent condition is to be found in the effects of the winter's cold, the more remote one in the wise ordination of providence. Artificial heat, as has been already stated in a former volume, will mature the perfect insect and make it burst from its prison at any period of the year; and, in like manner, artificial cold will retard its birth. From these considerations, it is obvious that the evolution of the imago depends on the evaporation and assimilation of the fluids, and this takes place in a more speedy or tardy manner, according to the greater or less degree of heat to which the pupa is exposed; it does not, however, happen that pupæ of the same species, placed in precisely the same circumstanc

always produce the imago at the same time; a difference of many months, even of years, has been observed in certain instances, an anomaly which we have hitherto found no means of explaining, although it is not difficult to perceive that it may often tend to the benefit and even the preservation of the species.

The manner in which butterflies and moths make their escape from their pupa-case, when about to become denizens of the air, has been already explained,* and it only remains for us to say a few words respecting the mode in which this operation is accomplished among other tribes. The incomplete pupæ have a comparatively easy task to perform, as their limbs are each in a separate envelope, and when one is free it can assist in the extrication of the others. But the coarctate pupæ are enclosed in a common case, the texture of which is more than usually rigid and unyielding; unless, therefore, a special provision had been made for their liberation, their condition would have been nearly hopeless. This provision consists for the most part of a circular suture near the anterior end, where the head lies, which so weakens the adhesion of the end to the body of the puparium, that it can be pushed open from within like a kind of lid, and afford sufficient room for the inmate to escape; this lid, in some instances, consists of two semicircular pieces, which open like a pair of folding doors. Reaumur has made us acquainted with the singular fact that some kinds

* See volume of Nat. Lib. formerly referred to.

of Dipterous insects have the power of introducing air into their pupa-case for the purpose of forcing a passage out of it. The air is said to be introduced under the middle part of the head, which becomes inflated into a membranous vesicle, and thus acts upon the end or lid of the pupa-case, and, in time, forces it open. This singular lever is necessary in the case of the flies alluded to, in consequence of the substance of the puparium being so hard as to offer more than usual resistance.

Many subterraneous pupæ assume the perfect form beneath the ground, and others make their way to the surface before undergoing that change. In the former case, the insect remains where it was disclosed till it acquires sufficient strength and hardness to render it safe to force a passage upwards; the rose-chafer (*Cetonia aurata*,) continues about fifteen days, the cockchafer (*Melolontha vulgaris*,) and Oryctes nasicornis, nearly a month. This, however, would obviously be impracticable for soft winged insects, (such as moths, two-winged flies, &c.) and it is, therefore, necessary that they should reach the surface (whether it be of the ground or the rotten trunk of a tree,) while yet pupæ. We have mentioned the means by which the pupa of the goat-moth effects this, and a similar plan is followed by most others so circumstanced. Such pupæ as are enclosed in cocoons are provided with means for forcing a passage through this additional obstacle of which an account has been given when treating of the insects by which cocoons are usually constructed. Other peculiarities

exhibited by pupæ previous to the disclosure of the perfect insect will be afterwards given in the particular history of the Orders, to which we therefore refer.

Imago or Perfect insect. When an insect quits its puparium, it is said to be complete or perfect, because it has then gone through all its changes, has all its parts fully matured and developed, and is capable of executing all the functions peculiar to its nature. The sexual distinctions, in particular, are now manifested, and the species become capable of continuing their kind. The wings are unfolded, and by their means they may almost be said to become inhabitants of a new element. It is now, in short, that, considered collectively, they exhibit in an especial manner all that diversity of form, peculiarity of structure, beauty and variety of colouring and ornament, as well as those singular instincts and modes of life for which the class is so remarkable.

In considering the perfect insect in this place, we propose to give a view of its external and internal structure—in other words, of the exterior crust and organs as they appear to the eye, and of the internal parts as ascertained by dissection, or the anatomy properly so called. In so doing, we must necessarily render our account as general as possible, reserving the details of the modifications which the various parts undergo, till we come to treat of the separate orders; for it is, in fact, by these modifications that the various orders are constituted, and a review must, therefore, be taken of all the most important parts of structure as introductory to each, before it can be fully

understood in what its peculiar characters and attributes consist.

The external integument, or crust of insects, occupies the place of the skin in higher animals, as it forms a general envelope for all the parts; but, unlike the skin, it is of a rigid and horny consistency. In the latter particular it is liable to a good deal of variation, being sometimes horny and inflexible, (as in beetles,) at other times comparatively soft, and yielding to the slightest pressure. In all cases, however, it has sufficient strength to give effectual support to the muscles, which are attached to its interior surface, thus serving the same purpose as the bones of the vertebrata; on this account, insects have been sometimes described as bearing their skeleton externally. Besides resembling the true skin in its situation, it is found to display further conformity to it, in consisting of three principal layers, viz. the epidermis or exterior layer, the rete mucosum, and lastly, the leathery tunic, sometimes called the dermis or corium. The first of these is smooth, shining, and generally uncoloured, for the most part thickly perforated with small holes, through which the hairs rise to the surface. The mucous tissue (*rete mucosum*) consists, according to Strauss, of two layers, the upper of which is closely attached to the epidermis, and in this reside the brilliant colours with which so many insects are adorned.* The third layer is without colour, and

* Except, of course, the Lepidoptera, in which the colours, as is well known, are produced by a superficial covering

consists of various strata of complicated fibres, which admit of being separated from each other. It is from this skin that the hairs originate, and from which they derive their nourishment.

In regard to chemical composition, the external covering approaches to the nature of horn, but it differs from that substance by the admixture of a peculiar substance, viz. chitine or entomoline. Portions of phosphate of lime and magnesia are also constituent ingredients, although they exist in small quantities. One of the peculiar properties of chitine is its insolubility in potass. "Exhibited separately, which is very easy, by means of steeping horny parts in a solution of potass, it appears as an almost colourless transparent substance, which becomes brown in nitric acid, and in the dry distillation produces no carbonate of ammonia, and therefore appears to contain no azote; it burns without previously melting, but is soluble in boiling or heated sulphuric acid.

"Besides the above, small portions of albumen, a peculiar brown colouring matter, which dissolves in caustic potass, but not in boiling alcohol, as well as traces of phosphate of iron, have been found in the horny integument of insects, upon different analyses. The albumen belongs doubtlessly to the third tunic, as does the brown colouring matter to the mucous rete: to this, also, we attribute the chitine, whereby the true horny skin, namely, the epidermis, will

scales: yet even these scales, according to Cuvier, obtain their colour from being, in the chrysalis, in a state of mucosity, similar to that which is found under the skin of the caterpillar.

be found to agree entirely with the horns of the higher animals."*

The integument is more or less obviously divided in a vertical direction into thirteen segments, and each of these segments has been supposed to consist of four parts intimately united, which would make the whole case consist of fifty two pieces.† But the three most obvious divisions, manifest to the most cursory observation, are the *head, thorax* and *abdomen.*

The HEAD is very variable in shape, but most commonly spherical, either the longitudinal or transverse diameter predominating. It forms a kind of box, having an aperture before and behind: the former is occupied by the organs of the mouth, the latter by the muscles, &c., which connect the head with the thorax. The whole of the lateral superficies is occupied by the eyes. Particular regions of it have received names from the analogy which they are thought to bear to the parts of the head in the higher animals, but scarcely two authors agree in their nomenclature and definitions. Considered as a whole, the cephalic box may be regarded as the skull, (*cranium*) since it encloses what is regarded as corresponding to the brain of the vertebrata. The upper portion of the skull extending from the region of the eyes

* Burmeister Manual of Entom.; Shuckard's *Trans.* p. 231

† "In many of these," says Mr. Newman, "each segment very evidently consists of a dorsal, a ventral, and two lateral plates or bones, which would produce the number two hundred and eight." *Ent. Mag.* i. 398.

backwards, is the *Epicranium*, the posterior portion of which, where the stemmata are often situated, is the *Vertex*. Bounding the epicranium in front and extending to the clypeus, is a space which has been called the forehead, (*frons*). The *clypeus* (*nasus* of Kirby, *Epistome* of Latreille,) occupies the anterior part of the head immediately above the mouth, it being apparently its office to guard the oral organs from injury. Sometimes the whole of the anterior portion of the head from the mouth to the region of the eyes, is denominated the face, (*facies*) and in certain tribes particular parts become developed, and consequently require to be indicated by additional names, which will be afterwards noticed. On the lower and lateral regions of the head, the following parts may be particularized: the *Gula* or throat, which lies immediately posterior to the under lip, and extends to the point where the head joins the prothorax: the cheeks, (*genæ*) composing the sides of the head from the eyes downwards to the mouth; the posterior portion of which lying in the vicinity of the eyes, is termed the temples, (*tempora.*) When the head is vertical or nearly so, the back part of it is called the *occiput.**

Such are the principal fixed parts of the cranium, if we add the eyes and ocelli; when others require to be definitely pointed out, they may in general be intelligibly named and characterised from their propinquity to other parts. We are now to notice the

* For delineations of the different parts of the head, thorax. &c. see Plate 1st, with the annexed explanation.

moveable parts, namely, the antennæ and the organs of the mouth. The former are the conspicuous and well known jointed organs, placed one upon each side of the head between the angle of the mouth and the eyes. They are never wholly absent, and never exceed or fall short of the number mentioned. They are planted in a cavity or socket, (*Torulus*) and the base is usually subglobose, forming the pivot upon which the antenna turns. Each of the joints of which they are composed has a separate motion, and they are therefore susceptible of every flexure the insect may require to give them. In regard to situation, general form and construction, number of joints, clothing, &c., antennæ vary greatly in different tribes, and their peculiarities in these respects will be specified when treating of these tribes separately.

The mouth of insects differs in its external appearance according as it is designed to act upon solid or liquid food; in other words, according as it belongs to a masticating or suctorial species. But although so dissimilar in external aspect, the component parts are essentially the same in both. In masticating insects, (*mandibulata*) the parts are free and highly developed; in suctorial species, (*haustellata*) they are more or less united, forming a kind of tube for the transmission of fluids. Although we have already described both these modifications of form, some recapitulation may be useful in this place, both for the purpose of presenting a continuous view of insect structure, and conveying as accurate a notion as possible of parts so essential, whether viewed in re-

lation to the insect's economy, or the uses that have been made of them by naturalists in their systematic arrangements of the class.

When a mouth organised for mastication is viewed from above, the first part that meets the eye is the *labrum* or upper lip. It is a corneous plate, of very variable form, united posteriorly by a membranous hinge to the clypeus, with which many authors, and among others Fabricius, have confounded it. It covers the mouth above, and assists in retaining the food while undergoing the process of mastication by the *mandibles*. The last named organs, otherwise called the upper-jaws, are two strong, triangular, wedge-shaped, or elongated pieces, placed immediately below the labrum, articulating with the head by means of apophyses or processes, and moving horizontally in opposition to each other like the blades of scissors. When of a horny substance, which is usually the case, they are commonly dentate on their inner edge, but the denticulations are seldom or never alike in both blades, but so arranged that the projections of the one enter the notches of the other, thus admitting of a close union. The *maxillæ*, or feeler-jaws, as they have not inappropriately been called, are placed below the mandibles, and correspond to them in being two triangular hooks, moving horizontally in opposition to each other. They are always smaller than the mandibles, usually of a more delicate texture, and instead of being toothed on their internal edge, are for the most part fringed with hairs or bristles. They may

be regarded as divisible into four parts: the insertion or hinge, (*cardo*) which is the lowest portion by which it articulates with the throat, and which is usually placed nearly at right angles with the following part. The latter is the stalk, (*stipes*) generally pretty strong and thick, at least in its upper part, although frequently it is soft and membranous beneath. Attached to this, on its outer side, is a small portion which has been named the feeler-bearer (*squame palpifère* of Strauss,) because the maxillary palpus is always inserted on its outer edge. The terminal portion of the maxilla, which usually appears in the shape of a hook,* ciliated on its inner edge, and frequently toothed at its extremity, is the maxillary lobe, (*internal lobe* of Latreille, *lacinia* of Macleay.) This, which is an important part, as it acts immediately upon the food, is very often simple, but at other times it is divided into two pieces, in which case the one is called the external, the other the internal lobe of the maxilla. The external lobe is sometimes called the galea or helmet, (this is its appropriate name among the Orthoptera) but when it is jointed and palpiform, as it frequently is among the carnivorous Coleoptera, it is commonly described as the internal maxillary palpus. The maxillary palpus properly so called, is a pretty long, jointed, commonly filiform process, the presence of which always distinguishes the maxillæ from the mandibles. The

* The lobe of the maxillæ is occasionally terminated by a moveable claw, as may be seen in certain Orthoptera and the tribe of Cicindelidæ or tiger-beetles.

figure and proportion of the joints are very variable; the terminal joint especially exhibits a great variety of forms, which are of great service in distinguishing genera. The number of joints never exceeds six.

Closing the mouth on the underside is a piece which acts as an antagonist to the upper lip, and has therefore been named the *under lip* or *labium*. The basal portion of this constitutes the mentum or chin; which is a quadrangular, trapezoidal or semicircular plate. The part immediately adjoining this and anterior to it, is the labium properly so called, usually bearing the labial palpi. The terminal portion is the ligula or limb, frequently divided into lobes. The labial palpi are similar in structure to the maxillary pair, but they always consist of a smaller number of joints, the greatest amount never exceeding four.

The tongue (*lingua*) is usually a very obscure member of the trophi, and authors do not always assign that name to the same organ. It may be described as the lining membrane of the under lip, the anterior angles of which sometimes protrude in front, as may be seen among the *Carabidæ*, a tribe in which the projecting points have been named paraglossæ. It is most distinct among the orthoptera.

On examining a mouth formed for suction, it appears, at first sight, to be constructed on such a different model from that just described, that it seems almost a hopeless case to attempt to trace any analogy between the parts. But it is not long before we can discover an essential agreement, although the

various organs are, of course, greatly modified, some being more fully developed, and others becoming almost or wholly obsolete. Three principal types of form in the construction of the mouth prevail among haustellate insects, which have received the names of *Promuscis, Proboscis,* and *Haustellum.* Each of these is characteristic of a particular order, and will therefore demand a detailed examination in the subsequent exposition of the peculiar characters of these orders; at present it may be merely remarked, that the tube for the transmission of the fluids is generally formed by the elongation of the maxillæ, accompanied with some accessory parts, sometimes the upper, at other times the under lip forming a lengthened sheath to support and protect the other parts.

The next primary division of an insect which requires attention is that which may be described generally as lying between the head and abdomen, viz. the Thorax. It is a highly important part, in as much as it bears all the organs of motion, and determines in some degree the whole shape of the insect; the variety of its forms and the multitude of pieces entering into its composition, render the study of it rather difficult, and this difficulty has been increased by the complex nomenclature which has been assigned to its parts. A slight inspection suffices, for the most part, to shew that it is made up of three principal parts; the anterior of these, bearing the fore-legs, is termed the *prothorax;* the next, which supports the middle-legs and the fore-wings, (in such species as are provided with four wings,) is the *mesothorax;*

and the hinder section, to which the hind-legs and hind-wings are attached, is the *metathorax*. In apterous insects these divisions are the only ones distinctly determined, but in those provided with wings a more complex arrangement results from the muscular apparatus requisite to produce their movements.

In its greatest state of development, (which it attains among the coleoptera and orthoptera,) the prothorax (*Manitrunk* of Kirby,) forms that large, quadrate, rounded, or oblong piece intermediate between the head and abdomen, which, in popular and descriptive language, is simply called the thorax. Its surface is the *pronotum* of Burmeister, the *thoracic shield* of Kirby. Its forms are too diversified to be specified here; it commonly has an impressed line down the centre, at other times the centre rises into a longitudinal serrated ridge. The inferior plate is named the *prosternum* by Burmeister: (*Antepectus*, Kirby,) it is of more limited dimensions than the surface plate, and usually projects into a kind of angle beneath; the anterior legs are inserted, one on each side, towards the middle, and the prothoracic spiracle is commonly a little behind them. Viewed from above, the prothorax sometimes forms merely a narrow ring like a collar, and in certain tribes all traces of it disappear in the dorsal aspect, the head being apparently articulated directly with the mesothorax. The various changes of form which the prothorax, as well as the other primary divisions, undergoes in the different orders, together with its appendages, and the degree of development

servable in particular parts, will be afterwards ced as these orders pass successively under our view.

The mesothorax is not always readily recognised its situation as intermediate between the prothorax d metathorax, for, as above intimated, it frequently pears in direct connection with the head; but it ay always be known by supporting the fore-wings d middle pair of legs; its anterior part is sometimes ceived into a cavity of the prothorax, when the ter is highly developed superiorly, at other times e union between the two is by the edges. So timately is it soldered behind to the metathorax, at there is frequently no visible suture, but in many stances traces of the union can be detected. According to Burmeister, (whose nomenclature of the rts in question appears to us preferable to that of ost authors, on account of its greater uniformity and mplicity,) this section consists of seven pieces, it, as three pairs of these are so closely united that ch pair seems to form only one piece, it may be garded as composed of four principal parts; the st of these, the *mesonotum*, (corresponding to the rsolum and scutellum of Kirby and Spence,) forms e dorsal covering of the mesothorax. In many sects it is almost invariably concealed, but in hers it is exposed and conspicuous; in such cases s form is usually square, and there is a superficial dication of its consisting of two parts; the one of ese, the true back, exactly corresponds to the rsolum of Kirby, the other is the *scutellum*, which

appears as a triangular piece interposed between the wings at their base; it is very conspicuous in most beetles, and, in the heteropterous section of the hemiptera, it is sometimes so large (as in *Tetyra*, Fab.) as to cover the whole abdomen, having both the hemelytra and the wings beneath it. In certain cases there is no indication of the scutellum on the surface, in consequence of it being covered by the elytra and pronotum, but it is always present, although the insects in question (Copris may be given as an example,) have been called *exscutellati*, or destitute of a scutellum. A strong membrane or process may be frequently observed connecting the scutellum with the elytra or upper wings, and acting as a kind of counter-check to the latter during flight. This is best seen in the great lanthorn-fly, (*Fulgora lanternaria*,) where there is a flat plate on each side of the scutellum, with a ridge or nervure running along it to the base of the tegmina, which nervure consists of a number of cartilaginous rings, and thereby admits of tension and relaxation, as the tegmina rise and fall. The part in question has been named the *frenum* or bridle.

The *scapulæ* constitute the second principal portion of the mesothorax. They lie close upon the mesonotum, one on each side in front, assisting to form the articulating socket of the superior wings; they then contract themselves, in order to pass into the cavities of the prothorax, and, with their opposite wing, they pass down the sides of the second thoracic segment. They admit, therefore, of being regarded

of two divisions, which may be distinguished as ie anterior and posterior wings of the scapulæ.*

The spiracle of the mesothoracic segment, which ad been long overlooked, owing to its latent posi- on, is found beneath and a little beyond the poste- or wings. The *patagia* and *tegulæ* of the Lepidop- ra and Hymenoptera, (which we shall afterwards lude to, when considering these orders) are attached, ie latter to the mesonotum, the former to the poste- or wing of the scapula.

The *mesosternum* forms the under side of the iesothoracic case, being directly opposite to the iesonotum. It is in all cases distinct, and some- imes comprehends a considerable area, in which the ockets of the middle legs are included.

The only primary segment of the thorax remaining o be considered, is the Metathorax which, like that ast described, supports a pair of legs and a pair of vings. It does not attain a high degree of develop- nent in any of the orders, except among the Coleop- era and Orthoptera; its structure, consequently, can e most satisfactorily investigated in these. It may ikewise be regarded, according to the authority we ave chiefly followed in describing the constituent arts of the thorax, as consisting of seven pieces, which bear considerable resemblance to those of the mesothorax. The dorsal portion is the *metanotum,* commonly quadrangular, with the front emarginate and the anterior angles consequently advanced. The

* Burmeister's Manual, p. 31.

scutellum sometimes extends over the anterior edg
of the metathorax; in some instances it entirely cor
ceals its surface. An impressed line sometimes sepa
rates an anterior portion from the rest, and in such
case this is called the *Postscutellum.* As the interna
cavity of the mesothorax is separated from that o
the metathorax, by a partition denominated th
Mesophragma, so the latter is separated from th
abdomen by a similar parietal wall, called the *Meta*
phragma, a small space only being left for the passag
of the necessary organs. The ventral plate of th
metathorax is the *metasternum,* a portion whic
most commonly assumes a shape similar to that o
its counterpart above, but it varies greatly in som
of the orders. On each side of the thoracic segmen
now under consideration, are found two horny pieces
which Kirby and Spence have named *plura* an
periplura. In the latter, the halteres or poisers o
Dipterous insects are situated.

We have now to consider the organs attached to th
thorax, by which motion is effected either on the lan
or in the air, viz. the legs and wings. The former ar
never wanting, and their number is invariably the same
the latter are often absent, and when present, thei
number varies from two to four. Such kinds as posses
four wings, are called *Tetrapterous* insects; those wit
two, *Dipterous;* and when altogether wanting, th
species are said to be *Apterous.* The point at whic
the wings are inserted, has been already indicated
they articulate to the thorax by means of numerou
small pieces. Viewed relatively to each other, th

mesothoracic pair is called the anterior, upper, or primary wings; the metathoracic pair, the posterior, under, or secondary wings. When a single pair only exist, they are attached to the mesothorax, except in one recorded instance, the *Aschiphasma annulipes*, which has posterior wings without the least trace of an anterior pair.

In general form, structure, and relative size, they undergo a great variety of modifications in the different orders; and it is from these modifications that the respective orders derive their names. Sometimes all the four are of similar membranous structure, and either all equal in size, (*Neuroptera,*) or the anterior pair largest, (*Hymenoptera,* &c.) At other times, the anterior are rigid and horny throughout their whole extent, (*Coleoptera,*) or only on one-half of their surface, (*Hemiptera Heteroptera.*) In some instances, (*Orthoptera,* &c.) the anterior wings are what is called *pergameneous*—that is, of a substance between coriaceous and membranous, or somewhat resembling parchment.

The harder the substance of which wings are composed, the less active is the share they take in flight. When they consist entirely of a hard horny substance, (as among the Coleoptera,) they can be subservient to this use in a very trifling degree; their primary and important function being to protect the inferior wings and the abdomen. They are, accordingly, distinguished by a name significant of their use, namely, *elytra,* sheaths or coverings. In proportion as the membranous portion of the wing gains upon the denser part the wing becomes a more efficient

instrument of motion. From this circumstance, a gradation can be traced, as to the share the upper wings take in flight from the Coleoptera to the Hemiptera, and from these to the Orthoptera. The insects possessing the greatest powers of flight, must, therefore, be sought among those in which the upper wings are wholly membranous; and we accordingly find them among the Neuroptera, Hymenoptera, and Lepidoptera. Every one who has paid the slightest attention to the subject, must have noticed how much more vigorous and sustained is the flight of a dragon-fly, a bee, or a butterfly, than that of a beetle, a grasshopper, or a plant-bug. The under wings are in every instance membranous, and are exclusively organs of flight.

A wing of the latter sort, whether it belong to the superior or inferior pair, has the external appearance of a firm, dry, membrane, usually transparent, and traversed by numerous salient horny ribs. Although the membrane appears simple, it consists, in reality, of two membranous leaves, closely applied to each other, and enveloping the ribs just spoken of. This can be made to appear very distinctly when the insect has just emerged from the pupa and immersed in spirits of wine, as the fluid can be introduced between the still flaccid membranes, and thus distends them like a bag. Even this membrane, which appears of the finest and most glossy surface to the naked eye, is found under the microscope to be clothed more or less densely with hairs; and in some gnats* these

* See the immensely magnified figure of a gnat in Swammerdam's Book of Nature, PLATE XXXVI.

hairs assume a lanceolate shape, and spring like small leaflets from each side of the longitudinal nervures. In assuming this form, they make an approach to the scales of the Lepidoptera. These hairs, doubtless, serve the purpose of preserving the wings from the lacerations to which they would be exposed from the nature of the places which the insects frequent for food; and, particularly, in the case of many of them, when constructing their nests. In addition to this use, M. Chabrier is of opinion that they may likewise contribute to fix the atmospheric fluid on the wings during flight, and thereby increase their buoyancy.

The ribs alluded to, ramifying over the surface of the wing, are properly called *nervures*. They are horny tubes, whose office it is to support and give tension to the membrane. A transverse section shews that they contain a soft parenchyma, and a large spiral vessel, accompanied by a fine nerve. This spiral vessel is a genuine trachea, emanating from the cavity of the thorax, and therefore adapted for conveying air throughout the wing. The nervures are usually uninterrupted, but in some instances, particularly among the Hymenoptera, (especially such as have a petiolated abdomen,) their continuity is frequently broken. This takes place chiefly at the points where they anastomose with each other, and the place where it occurs presents the appearance of a small transparent spot, resembling an air bubble, which led Jurine, who first noticed it, to call it a *ulla*. The nervures there lose their tubular form, nd become scattered in the shape of very fine

threads, but immediately reunite and recover their former figure. The substance of the nervures being thus spread over a greater surface, necessarily loses its usual depth of colour, and the transparency which distinguishes these spots is the result. The trachea however, is never interrupted. These interruptions are always accompanied by a slight fold of the membrane of the wing, and when the direction of this fold changes they change along with it. It is thence inferred that their principal object is to admit of a slight distention of the wing, when circumstances render that necessary, and make it more flexible, the nervures being too rigid for that purpose.

The longitudinal and transverse nervures, by intersecting and anastomosing with each other, enclose small spaces of the surface of the wing, which are called *areolets* or *cells*. These are pretty constant in their forms and position in the several orders and families, and therefore will be described hereafter as aiding in the discrimination and determination of groups. Kirby regards the wings of all insects as divisible into three longitudinal *areas*, which he names and defines as follows: *costal area*, the longitudinal portion of the wing that lies between the anterior margin and the postcostal nervure; *intermediate area*, the longitudinal portion lying between the postcostal and anal nervures: *anal area*, the portion between the anal nervure and the posterior margin.

The names given to those parts of a wing which determine its general form, require to be accurately defined. The part by which the wing articulates

with the thorax is called the *base;* the extremity opposite to this is the *posterior margin;* the *anterior* or *exterior margin,* (sometimes called the *costa,*) is that which is most advanced in flight, lying in the direction of the head, and the *interior margin* is the one opposite to it. The angles formed by the meeting of these margins are, the *anterior angle,* formed by the meeting of the anterior and posterior margins, sometimes called the apex or apical angle; the *posterior angle,* formed by the posterior and interior margins; in the hinder wings this is frequently termed the *anal angle.*

It may relieve the tedium of descriptive and technical details, which are often unattractive although indispensable elements of knowledge, to allude for a moment to the play of fancy in which authors have indulged in regard to the analogical relations which the wings of insects bear, both to certain bodily parts of other animals, and of insects themselves. Jurine compared them to the wings of birds, and in this he was followed by Chabrier. Latreille, after a laborious investigation, arrived at the unexpected conclusion, that they are true feet, merely modified in their situation and uses! Shortly after, M. Blainville discovered that wings are nothing else than exterior tracheæ, an opinion which Latreille subsequently inclined to adopt. Nearly at the same time, our countryman MacLeay, conceived the notion that they represent four of the legs of the decapod crustacea. Amid this perplexing diversity of opinion, a German naturalist, M. Oken, comes to

our relief; and solves the difficulty by affirming that membranous wings are desiccated branchiæ analogous to the branchiæ of fishes; and, moreover, that elytra are the analogues of the shells of bivalve mollusca!! Mr. Kirby is disposed to consider them as having some relation to the membranous expansions found in certain Saurian reptiles of the genus Draco; but wisely refrains from doing more than merely throwing out the hint that such may be the case. It is surely more natural to regard them with M. Audouin, as organs *sui generis*, destined to exercise a particular function, and undergoing such modifications as best adapt them for fulfilling that function in every variety of circumstances.*

As the wings occupy the superior portion of the thorax, and serve for aërial motion, so the legs are appropriated to the lower, and furnish the means of moving on the earth and in the water. Their number never exceeds or falls short of six; this rule being so invariable, that any articulated animal found not to conform with it, may at once be concluded not to belong to the class. Their position has been already indicated; a pair being appropriated to each of the three principal divisions of the thorax, and their distance from each other at the points of insertion depends on the greater or less extension of these divisions on their inferior or sternal face. They are distinguished as the *fore*, *middle*, and *hind* legs.

The joint which unites the leg with the body is

* See Lacord. Intro. à l' Entom. I. 409.

the *coxa* or hip, which is received into an acetabulum or socket, where it is suspended by a ligament. Frequently it is of a globular form, more or less surrounded and enclosed by a horny substance; at other times it forms a truncated cone, and appears attached to the thorax by the greater part of its base. When of the former shape, its motions are free and versatile; when of the latter, they are more restricted. In intimate connection with the coxa, but capable of independent movement, is a small piece named the *trochanter*. Its form is subject to many changes, but it is most commonly triangular or quadrangular, often prolonged into a lateral point. It articulates with the coxa, sometimes by ball-joints entering corresponding sockets, or simply by a membrane, the latter being generally the case when the shape is annular, as among the Diptera. Its union with the succeeding part of the leg, namely the *thigh* (femur), is usually much closer. The thigh, in far the greater number of instances, is the largest and most conspicuous joint of the leg. It is usually thick and robust; in form cylindrical, or compressed; straight, or arched; slender at the base, and incrassated at the middle or apex, &c. Sometimes the anterior thighs are longest and thickest, (*Acrocinus longimanus, Nat. Lib. Coleop. pl.* 21, *fig.* 1,) occasionally the middle pair (*Onitis*), and in all the saltatorial tribes, and many besides which do not leap, the hinder pair are greatly enlarged, (*Haltica, Locusta, Sagra*). The thighs are less frequently furnished with foliaceous and other appendages than that part of the leg next to be

described, but many instances of the contrary will be afterwards adduced. A range, or a double range of spines on the underside is frequently observed, and when these are absent, their place is often supplied by a fringe of hair or strong cilia.

The next portion of the leg is the *tibia* or shank, which, when the insect is in motion, usually forms an angle with the thigh. It is connected with the latter by that kind of articulation called ginglymus. Although frequently as long as the thigh, it is commonly much more slender. With respect to form, it is, for the most part, slender at the base, and gradually increases in thickness to the apex; in many instances, however, it is of the same thickness throughout. It is often compressed, arched, or flexuose, assuming the latter form to adapt itself to the inequalities of the thigh, when it requires, as is frequently the case, to be closely applied to that part. A transverse section is most frequently triangular; sometimes quadrangular or round. The variations in other respects which tibiæ undergo, are too numerous to be specified in this place; but one character is so conspicuous as to claim some attention even in the most general view of their structure, namely, the teeth, spines, and spurs with which they are so frequently armed. The teeth are most remarkable in the fossorial species, and are usually largest in the anterior tibiæ; when very prominent, the part in question is often said to be palmated. The spines are either processes of the horny substance, or they are articulated, and have a free motion;

in the latter case, they are called *spurs* (calcaria). The spinous processes are often arranged in a double row on each side of the tibia beneath, having a kind of groove between them; the spurs are most frequently placed in pairs at the extremity or middle. The prevailing arrangement is two at the extremity of each of the tibiæ; sometimes there is only one, and not rarely two on the middle and hinder tibiæ, and one on the anterior.

The terminial division of the leg is the *tarsus* or foot, which consists of a series of small, usually heart-shaped or triangular joints, never exceeding five in number. It is connected with the tibia by ginglymus, and the joints are closely united to each other, so as to present a uniform surface beneath. It admits of considerable flexure, a property indispensable for executing the functions that have been assigned to it. The first joint is in general longest, and the last next to it in length; the fourth (which is often bilobed) shortest. The terminal joint is commonly clavate, and bears either one or two claws at the tip; the latter number being by far the most general. These claws are simple, bifid, dentate on their under edge, or serrate. Between the claws we often perceive a smaller one, which is named the spurious claw (*pseudonychia*), and in many families two small membranous cushions are present, which act like sucking cups, and enable the insect to support itself against gravity. Membranous lobes of a similar kind are frequently attached to the underside of the tarsal joints. The whole of the underside (or sole,

planta,) of the tarsus is frequently clothed with very thickly set short hairs, forming a covering, which has been called the *foot-cushion,* (pulvillus). Other peculiarities connected with this section of the leg will appear when we come to examine it in the different orders. The number of the joints has been found to afford very convenient means for forming sub-divisions in the several primary sections, as they are ascertained to be pretty uniform in nearly allied species. Such as possess five joints in all the tarsi are called *pentamerous;* those having five joints in the fore and middle legs, but only four in the hinder pair, *heteromerous;* when all the tarsi are four jointed, *tetramerous;* three jointed, *trimerous;* two jointed, *dimerous;* and lastly, such as have only one joint are termed *monomerous.*

Owing to the fore legs frequently presenting a structure different from the rest, adapting them for becoming instruments of prehension, Mr. Kirby thought they made so near an approach to *arms,* that he applied to them that name. The five portions described above, would, in this view, be regarded as analogous to the clavicle, scapula, humerus, cubitus, and hand. Although many remarkable appearances might be cited in support of this view, yet it is obvious that the primary use of these limbs as instruments of motion is never superseded, and we are not entitled to bestow a new name on an organ merely on account of a few slight modifications of structure, or because it has been made subservient to certain additional uses. It is not, besides, in all cases the fore legs that supply the place of arms; in

some instances the hind legs are most developed, and are far most employed in furthering the insect's economy. This may be witnessed in the pill-rolling beetles, (*Ateuchi.*)

We have now briefly considered two of the principal sections of the body, the head and thorax, and it only remains for us to bestow a similar notice on the third, namely, the ABDOMEN. This portion is at once known by the absence of all external articulated appendages similar to those of the anterior segments, and a greater simplicity of composition, consisting merely of several consecutive horny segments or rings, in all cases closely joined, and in some instances overlapping each other. The greatest amount of these segments is nine; for the entire number in an insect never exceeds thirteen, and of these one is formed by the head, and three are occupied by the thorax. It often happens, however, that the number seems much less, in consequence of several being united, or so overlapping each other that they cannot be observed. In general the dorsal segments seem more numerous than the ventral; although the reverse of this obtains in some instances. A difference in this respect is not unfrequently a sexual distinction. The shape is too various to admit of a determinate definition in a few words, but a transverse section very generally makes an approach to a rectangular triangle, the base being uppermost. The mode of attachment to the thorax is nearly the same in all cases, although there is an apparent difference depending on the shape of the basal portion. When the latter is broad, as in conical shaped abdomens

the base appears united by its whole circumference to the metathorax, a suture alone indicating the point of junction; in such cases the abdomen is said to be *sessile*. A very narrow point, in other instances, forms the whole bond of connection, the base being contracted into a slender trumpet-shaped tube, which scarcely appears of adequate dimensions to transmit the vessels requisite for maintaining life; such an abdomen is said to be *petiolated*.

The segments of the abdomen may be regarded as composed each of two arches, a dorsal and a ventral one; but analogy inclines us to believe that these are made up of several subordinate parts, although it is often impossible to point out their boundaries. In the *Staphylinidæ*, for example, there is a lateral portion, in the shape of a parallelogram, on the upper side of each of the ventral arches, united by a line or articulation to the membranous part. These pieces, which M. Strauss was the first to notice, and which he named lombar pieces, (*pièces lombaires*,) are probably analogous to some of the lateral plates of the thorax. The segments articulate with each other in two principal ways. In the first, the superior arches cover each other more or less, or simply touch at the edges, while the lower ones are soldered together by the middle, and the sides alone left free. The result of this arrangement necessarily is, that the former alone are susceptible of dilatation, and the abdomen greatly restricted in its powers of expansion and movement. In the second, each segment is covered by that which precedes it without any union at any part, so that they slide into each other like the tubes

a telescope, and can readily be moved in any direc-
n. Such a confirmation is well exemplified by the
aphylinidæ, which elevate and twist about their
domen with the utmost facility, and even turn it
er the back to push the wings under their short
ses.* The whole of the segments are lined in-
nally with a soft membrane, which connects
em, and retains them in their places, without im-
ding their movements. This membrane becomes
ible when the abdomen is in a distended state, as
a gravid female, when the abdomen seems to form
bag, with horny plates arranged in a certain order
er its surface.

An opening for the respiratory organs, which
mify through the body, may be observed near the
teral margin of each segment. These openings are
rrounded with a hard ring, and are called spiracles
air-holes, (*Stigma, Spiracula.*)

It has been well observed that each of the three
eat divisions of the body is the appointed seat of a
parate set of organs, all of them alike important in
e animal economy. As the head contains the
gans of mastication, and the thorax those of mo-
on, so the abdomen is the appropriate site of the
enerative organs. These, however, are chiefly in-
rnal, and will be most conveniently considered
hen treating of the anatomy of the abdomen. Such
xternal appendages, too, as are more or less acces-
ory to the organs aliuded to, as well as various others
hich, as far as known, have no connection with

* See Lacord. Introd. I. 447.

them further than that of juxta-position, will fa
under our notice afterwards.

Explanation of Plate 1*st.*—Fig. 1. Head of Mylabris, upp
side:—*a*, forehead; *b*, vertex; *c*, occiput; *d*, *d*, temple
e, *e*, eyes; *f*, torulus, cavity for the insertion of t
antennæ; *g*, clypeus, (of Fabr.) nose, (of Kirby
Epistome of Latreille; *h*, labrum.

Fig. 2. Under side of same head:—*k*, posterior orifice; *l*, t
neck; *m*, the mentum; *o*, the eyes; *p*. mandibles
s, labial palpi.

Figs. 3, 4, 5. Forms of the Labrum:—Fig. 6. Mandible
Hydrous piceus; Fig. 7. Do. of *Goerius;* Fig. 8. Do.
Calosoma sycophanta.

Fig. 9. Maxilla of *Necrophorus germanicus:*—*a*, maxillary pa
pus; *b*, external lobe of the maxilla; *c*, internal lob

Fig. 10. Maxilla of *Cicindela:*—*a*, external maxillary palpus
b, internal do. or exterior lobe of the maxilla; *c*, int
rior lobe, with an articulated hook at the apex, *d*.

Fig. 11. Maxilla of *Hydrous piceus:*—*a*, insertion or hinge
b, dorsal piece; *c*, squame palpifere of Strauss; *b*, *c*,
taken together form the stalk, (*stipes;*) *e*, external lob
f, internal do.

Fig. 12. Labium of *Cychrus rostratus:*—*a*, mentum; *b*, ligula
c, *c*, labial palpi.

Fig. 13. Labium of *Carabus*, inside:—*a*, mentum; *b*, lingua
c. paraglossae.

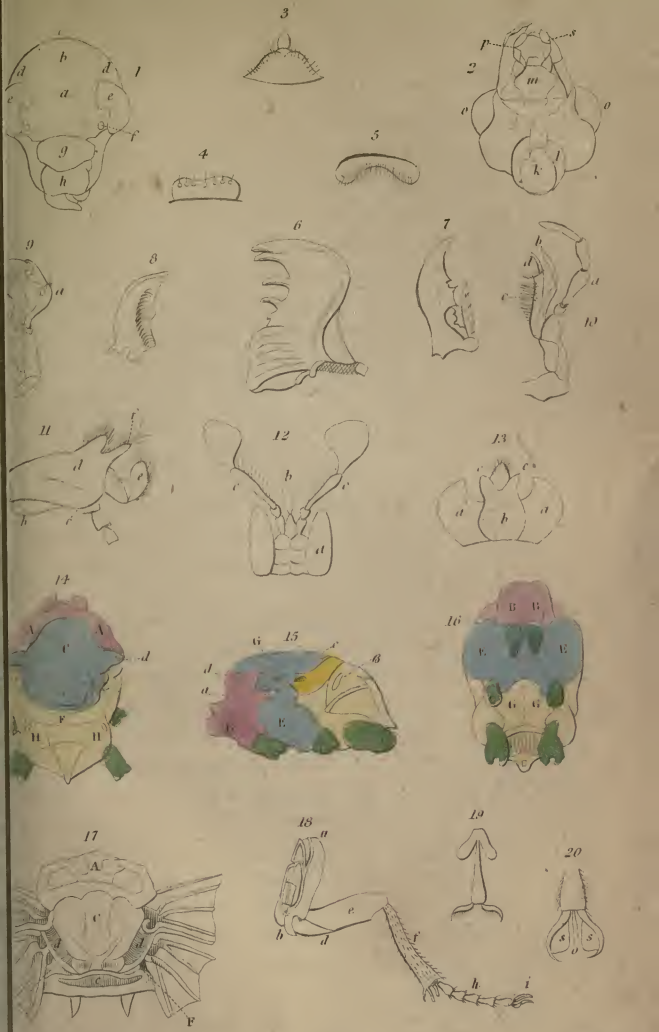
Fig. 14. Thorax of *Scolia flavifrons*, upper side, the red colou
indicating the prothorax, blue the mesothorax, an
yellow the metathorax; coxæ, green:—A, the pron
tum; C, the mesonotum; *d*, *d*, patagia; *c*, scutellum
F, the metanotum; H, H, the parapleura.

Fig. 15. Side view of the same:—E, mesosternum; B, proste
num; G, metasternum; *d*, patagium; *c*, scutellum
a, first spiracle; *β*, second do. Fig. 16. The same fro
beneath:—B, B, prosternum; E, E, mesosternum
G, G, metasternum.

Fig. 17. Thorax of *Cicada Fraxini:*—A, pronotum; C, mes
notum; *c*, scutellum; *d*, *d*, frenum; F, F, metanotun

Fig. 18. Hinder leg of *Melolontha vulgaris:*—*a*, *b*, coxa;
trochanter; *c*, thigh; *f*, tibia; *h*, tarsus; *i*, claws.

Fig. 19. Pectinated claws. Fig. 20. Claws of an *Asilus:*—
o, central filaments; *s*, *s*, membranous expansion of th
terminal joint advanced beneath the claws.



Lizars sc.

EXTERNAL ANATOMY.

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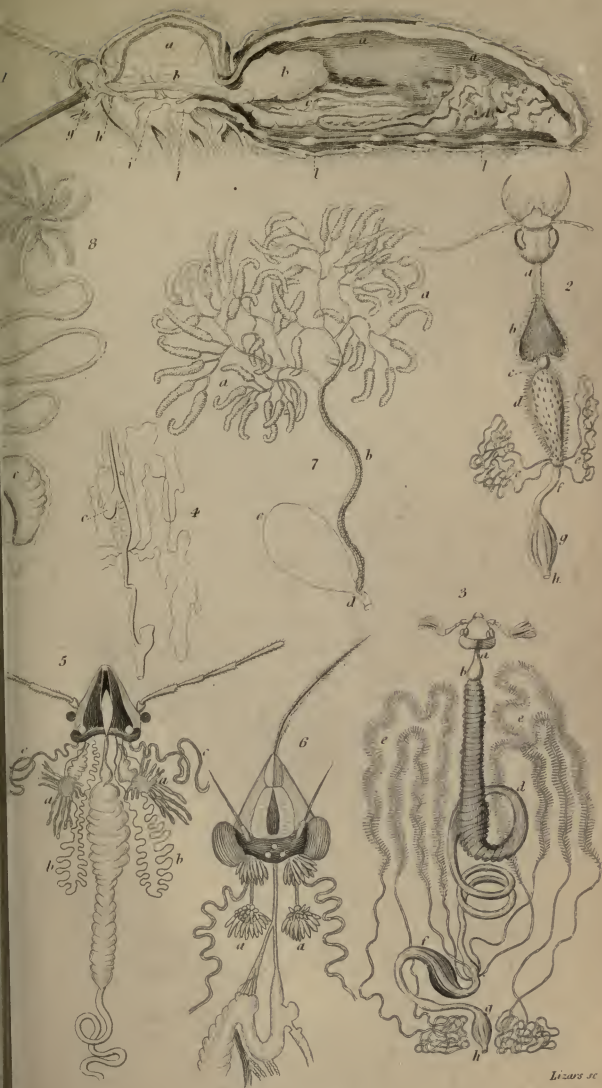
ANATOMY AND PHYSIOLOGY OF INSECTS.

HAVING thus traced the progress of insects from the time of their birth till they arrive at their full maturity, and likewise noticed the most remarkable features in their external conformation, it now becomes requisite to advert to their internal structure, and give a comprehensive view of the complex system of organs by which life is maintained. In these a very close analogy, for the most part, exists to the vital system of the higher animals; but in some respects curious and most important differences prevail. Viewing the animal kingdom as forming a progressive series, from the most simple to the most complex organism, insects may be regarded as occupying nearly the centre of the scale; for, though some properties might entitle them to rank higher, there are others in which they are so deficient, as completely to counterbalance that consideration. In muscular vigour, for example, and the complication of the digestive canal, they are almost equal to the vertebrata, while the circulating system is so imperfect, that it was, till lately, a matter of doubt whether it deserved the name. From these considerations, it may be inferred that the systems of organs are neither very complex nor very simple, and that in these respects, there is some degree of inequality among them.

They may be considered, together with their re
pective physiological functions, under the followi
heads: 1. Nutrition; 2. Sensation; 3. Muscul
System; 4. Reproduction.

NUTRITION.—As nutrition consists in the renew
of the molecules which constitute an animal bod
and as that is accomplished by means of the foo
we have only to consider the principal process
which the latter undergoes, in order to obtain
indication of the different heads under which th
department of the subject may most naturally
treated. The first of the most important changes
which the food is subjected internally, is its conve
sion into chyle, previous to which it is incapable
affording any nutriment; this process is called *dige
tion*, and takes place in a special organ named th
alimentary canal. But the chyle is not perfect
adapted to its nutritive functions till it has been broug
into contact with the atmosphere, in order to receiv
a supply of its vital principle, viz. oxygen. The
being no lungs in insects to which it can be conveye
as to a reservoir, to receive this supply, the necessit
is provided for by bringing the air into contact wit
it by means of small tubes ramifying through th
body; this process is called *respiration*. In conse
quence of the blood being aërated at so many place
instead of a particular point, often remote from th
extremities, there is no necessity for a rapid or gener
circulation of it; still, however, it is by no mean
stagnant, and its movement is called, although th
term is rather too strong, the *circulation of the blood*



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DIGESTIVE ORGANS &c.

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In the different stages of the nutritive process, certain substances are formed, which are sometimes essential to the animal economy, and at other times rejected as hurtful; these may be included under the general name of *secretions*. We shall successively advert to each of the subjects just enumerated.

Digestion.—As this function is almost entirely devolved on the organ named the *alimentary canal*, we shall endeavour, in the first place, to convey an accurate notion of the form and position of that important viscus. It may be described generally as an elongated tubular organ, occupying the centre of the body, and open at both extremities. Occasionally it is nearly straight and not longer than the body, but, in most instances, it is twisted on itself in numerous convolutions, and its length is consequently very considerable, sometimes twelve times as long as the body. In this respect it is found to vary, as among the higher animals, according to the nature of the food, being long and complicated in herbivorous species, and comparatively short in such as live by prey; but even this law is not without numerous and striking exceptions. In most cases the form is rendered irregular by many distentions and constrictions, which are so conspicuous that they may be regarded as dividing the canal into several parts, which have received different names according to the functions they perform. The place occupied by the canal is the median line of the body, immediately beneath the dorsal vessel. (See Pl. II. fig. 1, *b*, *c*, *d*, *e*, *f*.) Its texture is not the same throughout its whole extent, but its essential con-

sists, as among vertebral animals, of three tunics or coats, the *mucous, cellular,* and *muscular,* the first being internal, and the others superimposed in the order in which they have just been named. The first is delicate and soft, without any decided texture, frequently transparent, and of such tenuity that its presence is not always easily detected. The second layer, (which Strauss names *membrane propre,* or proper skin,) is likewise for the most part smooth and thin, although it sometimes becomes thicker and spongy. It is generally almost without fibres, but, when highly magnified, a few globules or granulations appear, arranged transversely in its tissue. These have been called by Strauss, gastric glands. According to Leon Dufour, the membrane in question is entirely wanting in hemipterous insects. The muscular membrane is firm, fibrous, and contractile, surrounding and protecting the exterior, and distinct longitudinal and transverse vessels pervade its texture. It is it which causes the peristaltic movement of the digestive tube, and it forms the contractions and sphincters observable in different parts of it.

These contractions, as already intimated, form various divisions in the intestinal tube which have names assigned to them in accordance with their functions. The following divisions are recognised, the *pharynx,* the *esophagus,* the *crop,* the *gizzard* the *chylific ventricle,* the *slender intestine,* the *cœcum,* and the *rectum.*

Besides these integral parts of the canal, there are various vessels appended to it, which discharge juices

to it which are indispensable to complete the act of digestion; these are the *salivary, hepatic* or *biliary vessels:* along with which the *urinary vessels* will be noticed.

Before proceeding to the separate consideration of each of these parts, it is of importance to remark that they never all co-exist in the same species. Sometimes one is absent, sometimes another, and they are often found to differ materially in the same individual, according as we examine it in the larva or perfect state.

The *pharynx* cannot be very decidedly distinguished as a distinct feature, as it merely forms the distended aperture of the canal where it opens into the cavity of the mouth.* Indeed, it cannot be said to exist at all except among the mandibulated tribes, for, in a suctorial mouth, the esophagus is in strict continuity with the sucking tube; it can only be defined therefore as the distended opening of the esophagus in masticating insects. The mouth and pharynx are usually upon the same plane, but in such insects as chew the food for a length of time, it lies a little higher, doubtless for the purpose of preventing the aliment finding its way into the esophagus before

* Singular as the assertion may appear, some insects exist in which the alimentary canal has no opening at its anterior extremity. These are the bot-flies, constituting the genus Œstrus, which are, of course, incapable of taking nourishment. In a few instances the canal has its hinder extremity closed, as is exemplified by the larvæ of wasps and bees; these take nourishment, but require to void no unassimilating matter.

being sufficiently masticated. The part last named, otherwise called the *gullet,* (Pl. II. figs. 2, 3, *a*,) is a narrow tube intermediate between the pharynx (when such exists,) and the crop, or, in the absence of the latter, the gizzard. It commonly passes through the thorax in a straight line, and terminates at the origin of the abdominal cavity; but nothing can be more variable than its length. In certain Hymenoptera, (*Pimpla, Pompilus,*) it forms more than half of the entire canal; in the cockchafer, (Pl. II. fig. 3, *a*,) a small portion behind the head, scarcely one-sixtieth of its length; and all intermediate dimensions occur. The esophagus is in all cases simple, except among the Lepidoptera, which present the remarkable peculiarity of a bifurcation anteriorly, a branch emanating from each of the two spiral sucking tubes and uniting into one conduit, usually just behind the head. The *crop,* (Pl. II. figs. 2, 3, *b*, *b*,) has been so named by Cuvier, Léon Dufour, and Strauss, because it occupies the same position as the organ so called in birds; by some other authors it is denominated the stomach. It appears, for the most part, as a simple dilatation of the hinder part of the esophagus into a kind of bag, which is usually on a line with the other parts of the alimentary canal, but sometimes appears suspended at the side like a pouch. Its form is most variable, even in the same species, according to the degree of its repletion or vacuity. When the gizzard, the succeeding portion of the canal, is wanting, which is very often the case, the crop appears in its simplest form, and is unprovided with any secretion to act upon the

food; but when the part alluded to exists the crop is furnished with interior glandular organs which secrete an active juice. These glands are most conspicuous among the tiger-beetles, (*Cicindela*) even appearing in external rows on the obcordate shaped crop. (Plate II. fig. 2, *b*.) With very few exceptions besides this, the surface of the crop is quite smooth. These remarks, however, apply to this part only as it appears among masticating insects; in all other kinds, with the single exception of the Hemiptera, it becomes (or there is substituted in its place, according to the views we adopt regarding its origin,) what has not improperly been called a *sucking-stomach*. (Plate II. fig. 4, *c*.) Its function is no longer to receive the alimentary substances transmitted from the mouth, but to facilitate the rise of the fluids from the mouth to the principal receptacles of the alimentary canal. This it promotes by distending at the will of the insect, and thus rarifying the air in its interior and acting as a kind of pump. It presents various modifications of form in all the different tribes possessing it. The crop is succeeded by the *gizzard*, (Plate II. fig. 2, *c*.) which may always be recognised, when present, by having its internal surface covered with teeth, spines, or horny ridges; a structure which eminently fits it, in connection with its muscular, almost cartilaginous texture, for subjecting the food to a more complete trituration than it had previously undergone. It exists in all insects that feed on hard substances, such as wood, bark, &c., and in all carnivorous kinds; but not in those

that derive their nourishment from decomposed vegetable or animal matter. For the most part, only two of the membranes which enter into the general composition of the tunic of the intestinal canal can be detected here, the innermost of which is almost corneous and much folded. These folds are not accidental, but are arranged in a certain order, according to the genera and families. The gizzard is wanting in the larvæ of all insects which go through a complete metamorphosis. The *chylific ventricle*, (Plate II. fig. 2 and 3, *d.*) is the ensuing dilatation of the intestinal canal; an important cavity which, upon the whole, may be regarded as most nearly corresponding to the stomach of the vertebrata. The above name, assigned to it by M. Léon Dufour, is exactly expressive of its function, which is to contain the food, now reduced to a homogeneous and impalpable pulp, till it undergo the process of chylification. Its capacity is considerable, either arising from its width or length. Its termination behind is indicated by the insertion of the biliary vessels, or by a constriction separating it from the small intestine. In form, it is always more or less tubular, or tending to oval, but even within these limits the shape varies much. In the common cockchafer, (Pl. II. fig. 3 *d*,) it is contracted behind into a long tube, and twisted into several circumvolutions—a mode of disposition which it frequently exhibits in a still more complicated manner in some of the other orders. One of the most distinctive and remarkable characters of this ventricle, is the palpillæ or small

bags appended to its surface in certain tribes. They produce the appearance of a coarse villosity, (Pl. II. fig. 2 *d*,) but when examined with the microscope, they are found to be little bags, opening into the ventricle. They are formed by the internal mucous membrane, the other membranes not entering into their composition. The greatest diversity of opinion prevailed among physiologists respecting the functional uses of these appendages, but it seems now to be the most generally received opinion that they are secerning organs, and that their secretions act as solvents on the contents of the ventricle, particularly when these consist of animal matter, for it is among the carnivora that they are principally found. Other appendages sometimes occur characteristic of particular races.

The remaining portion of the nutrimental canal may be called the *intestine*. It is always more simple in form, considerably narrower, and more delicately constructed than the preceding divisions. The slight expansions and contractions which it offers in certain parts of its course, have led some to regard it as consisting of nearly the same portions as the intestines of the vertebrata, and they consequently recognise a duodenum, an ilium, a cæcum, a colon, and a rectum. If we were perfectly acquainted with the functions of these organs in insects, as has been judiciously remarked, it is possible that we might find reason for these numerous divisions, each having a special function allotted to it; but in our present uncertainty in this respect, we run less risk of error by

adhering to the more simple division and nomenclature indicated on a former page. It will be seen, moreover, that two of the parts which we have not regarded as entitled to a separate consideration, the duodenum and the colon, are thought to exist in only a very few species, and even then they are not particularised by any one constant character.

The intestine commences immediately behind the chylific ventricle, from which it is separated by an annular constriction or sphincter. This alone points out its origin, when the biliary vessels are placed towards the anus; but being usually inserted immediately beneath the sphincter in question, they then mark precisely its anterior limit.* The small intestine, in its ordinary state, is a slender simple tube, very variable in length. In general, it is a good deal shorter than the body, frequently shorter than the chylific ventricle, (as in the *Chrysomelidæ*,) sometimes it attains the length of the body, and in a few instances exceeds it. In certain cases it deviates from a simple tubular form, and becomes inflated more or less abruptly into a clavate or oval-shaped bag. This is well exemplified in the common cockchafer, (Plate II. fig. 3 *f*,) where it forms a large ovoid pouch, and presents, when distended, five projecting ribs, which correspond to a series of imbricated plates in the interior. In this case there is an additional inflation, of much smaller size, a little behind the principal one. "If the name of this por-

* Lacord. Intro. II. 33.

tion of the intestine," says Burmeister, speaking of that part which corresponds to what we have called after the French physiologists, the small intestine, "is to be determined from its divisional distance from the stomach, it must be considered as the true ilium, which is however contradicted by its function, which, like that of the cæcum of the glires of the mammalia, subjects the food to a second digestion and extraction before it is rejected. We are convinced of this by the comparison of its state in the stomach, and in this portion of the canal, for we find it here much more pappy than there, but not so viscous as in the colon."*

The *Cæcum* (Pl. II. fig. 2 *g*.) is that portion of the canal, behind the small gut, where the unassimilated parts of the alimentary substances, now completely deprived of their nutricious particles, begin to acquire a hard consistency, previous to their expulsion by the rectum. It is generally a direct continuation of the small intestine, but it is divided from it by a valve, which completely shuts up the opening. In some cases, however, the intestine is united to its side, and it forms a large ovoid vessel, as in *Dytiscus Rœselii*, and allied species. The external surface is frequently covered with papillæ, and the internal, particularly near the mouth of the small gut, with glandular warts, which are supposed to secrete a fluid to assist in the expulsion of the fecal matter. This segment of the canal is usually short, but it varies too much to admit

* Manual of Entom.; Shuckhard's Trans. 139.

of its relative dimensions being easily stated. The same remark applies to its form, although it most commonly inclines to oval. Its situation is more constant, for it always occupies the hinder segment of the abdomen. It frequently has a pouch-shaped appendage, originating at its commencement, which sometimes appears quite distinct from it, although their cavities are always connected with each other In this case there is no valve to separate it from the cæcum. From its having been noticed in all perfect aquatic insects, M. Léon Dufour regards this appendage as a kind of swimming bladder; but to this view there are great objections, among others, that which arises from the consideration that air could not have ready access to it. It is more probable that it is in some way subservient to defecation. The *rectum* is nothing more than the terminal portion of the cæcum: it is always short, and provided with a sphincter or strong annular muscle, which closes the aperture when not in action. Its muscular tunic is very thick, its parietes very variable in form, and it is from them that the excrements acquire their particular figure.

Having thus noticed the divisions of the great nutrimental tube, leaving some peculiarities to be noticed when treating of the respective tribes in which they appear, it is now necessary to advert to its appendages, which were stated to consist of the *salivary, biliary,* and *urinary vessels.* Insects are seldom provided with glands, properly so called, as a necessary consequence of the want of a perfect

circulation; their secreting and excreting organs are usually long, slender, and tubular vessels, floating freely in the interior of the body. The salivary vessels are most conspicuous among suctorial insects, but they likewise exist in others. They generally lie around the pharynx or the crop, and ascend into the cavity of the mouth by a meandering duct. Under all their changes of form, we can, without much difficulty, according to M. Léon Dufour,* recognise the following parts: 1. A glandular apparatus destined to secrete saliva, which is single, double, or even triple; 2. One or two excretory conduits, whose function it is to discharge the secreted liquid into the mouth or esophagus; 3. Bags or reservoirs in which the saliva is deposited and preserved. In *Scutellera nigrolineata*, the figure of which we have copied from the author just named, all these parts are distinctly exhibited. Pl. II. fig. 5, *a*, *a*, represents a large semi-diaphanous glandular piece, (greatly resembling a true gland,) composed of two lobes, the hinder of which is digitated; from each of these issues a very flexuose excretory duct, which debouches into the esophagus, (*b*, *b*.) The salivary reservoirs are, in this instance, slender and twisted, as is very often the case; (*c*, *c*.) *Cicada orni* presents a different arrangement, the secreting organs consisting of a mass of minute oval bags or bladders, divided into two bundles, which are united by means of a tubular canal; (Pl. II. fig. 6, *a*, *a*.) The anterior of these

* See his excellent work entitled, "*Recherches Anatomiques sur les Hémiptères*, p. 119.

is placed in the head, the posterior in the thorax. The excretory duct is of such tenuity, that, if it exists, M. Léon Dufour was unable to detect it. The prevailing number of these organs is two, one on each side; frequently there are four, and Burmeister asserts that no fewer than six are to be found in the genus *Nepa*, three on each side, all of them opening into the cavity of the mouth.

The peculiar fluid termed bile appears so indispensable to digestion, both in the higher and lower animals, that, in most cases, we find the organs destined to secrete it very conspicuous. In insects, what must essentially be regarded as such are always present, as far as yet known, except in the genera Chermes and Aphis. They assume the shape of filiform tubes, usually very long and flexuose, meandering over the surface of the chylific ventricle and the intestines. The point of the alimentary canal where they are generally inserted is just behind the pylorus; in a few instances they open into the chylific ventricle. In the whole of the order Hemiptera, the point of insertion is the place where the slender intestine meets the cœcum; an arrangement of which few examples are to be met with elsewhere. Sometimes they are inserted only by one extremity, the other being free, at other times they are fixed by both ends. In regard to number they vary extremely; *two* is the prevailing number among the Coleoptera, Hemiptera, and Diptera, *three* occur among some coleopterous tribes, such as the Cerambycidæ, *four* in many Diptera and a few Neuroptera, *six* in the Lepidoptera, *eight* in

certain neuropterous groups, such as the Hemerobii, and, in many instances, particularly among the Orthoptera and Hymenoptera, they amount to a hundred and fifty. Their length generally bears some proportion to their number, a deficiency the one way being compensated by an increase in the other The longest surpass the dimensions of the body five or six times. Although commonly of the same diameter throughout their whole extent, they are occasionally attenuated at one or both extremities. Numerous constrictions at regular intervals, in a few instances, give them the appearance of being granular or warty. One of the most notable deviations from their generally simple construction is witnessed in the cockchafer, in which they appear fringed with a double row of thickset projecting processes of equal length, some of which are furcate; (Pl. II. fig. 3, *e, e.*) their composition, also, is greatly more simple than that of the alimentary canal, the coat consisting of a single membrane of great delicacy. It is likewise transparent, permitting the view of the contained fluids, which are most frequently brown or saffron yellow; the prevalence of the latter induced Swammerdam to call the whole organs saffron-vessels.

The last system of vessels which we shall notice at present in connection with the alimentary tube, is that formed by the *urinary vessels*. In their general aspect they almost seem to repeat, at the anal extremity of the body, the salivary vessels appended to the head. But their presence seems to be far less general, or at least they are more difficult to detect,

or have been less carefully investigated, for a comparatively limited number of insects are mentioned as possessing them. Among these are the carnivorous Coleoptera, Dytiscidæ, Silphidæ, certain Brachelytrous species, a few Diptera, &c. Notwithstanding their occasional complexity, we can for the most part discern without difficulty an apparatus for secretion, one or more deferential canals, and a reservatory bag emitting an excretory conduit which empties itself into the rectum, just above the anus. The fluids secreted are commonly colourless, and highly caustic and odorous. These properties may be easily determined by taking one of the larger Carabi and handling it roughly, when it will probably discharge the fluid, which it does with considerable force in sudden jets, and if it fall on the skin, it produces a sharp burning sensation, which however is very transient. In *Carabus auratus* the vessels in question consist of two branches of globular bodies, one on each side, resting on a footstalk, connected with a long deferential canal, opening into a large ovoid bladder. *Chlœnius velutinus* (Pl. II. fig. 7, *a*, *a*,) has the secreting vesicles disposed on the tops of small branchlets, so that the whole apparatus looks not unlike a branch of a willow covered with catkins. In the same fig. *b* is the deferential canal; *c*, *d*, the bladder. Fig. 8 in the same plate, represents these parts as they appear in the *Bombardiers*, a kind of beetles which have been long famous for possessing the power of producing an explosion accompanied with a discharge of smoke. This is caused by the

rapid evaporization of the ejected matter, which appears as a white vapour of a very penetrating and powerful odour analogous to that of nitric acid. The mechanism by which this is produced, consists in the addition of a second reservatory bladder, placed behind the first, in which the change adapting the liquid for explosion is produced.* (Pl. II. fig. 8, *d*, accessory bladder; *c*, principal bladder.)

The structure of these organs is a little more complex than that of the biliary vessels, there being always two distinct membranes present; the interior one soft and delicate, the exterior frequently appearing annular or transversely folded.

Such are the principal parts and appendages of the great alimentary tube in which digestion takes place. As the preceding description refers to it chiefly in the perfect insect, it is necessary to add a few particulars in relation to its modifications in the larvæ, and the changes produced upon it by the phenomena of metamorphosis. When the latter is incomplete, not altering materially the external aspect, it is found, as might be expected, that the canal remains pretty uniform in all the different

* The insects in question constitute the genus *Brachinus*, some species of which are natives of Britain; but this singular means of defence is best witnessed in foreign Brachini, of larger dimensions, a few discharges from which cause such a burning sensation, that it is necessary to let the animal escape. The American genus Ozœna, Aptinus, and some of the Paussi likewise, possess this remarkable property. It has also been attributed to the very common Anchominus prasinus, but if rightly, it may be said scarcely to know its use, for few have witnessed its explosions.

stages of development. The striking changes in outward appearance implied by the terms complete metamorphosis, prepare us to expect some corresponding alteration in internal organs, and this, accordingly is found to be the case. The proportions of the different parts are not only different, but some of the parts found in the perfect insect are wanting in the larva, while others exist which disappear in the final stage. Such changes are indispensable when the larva lives on one kind of food, and the imago on another, (as in the Lepidoptera, for example,) but they likewise occur in cases when the food is the same in both conditions. In the larva of the carnivorous Coleoptera, for instance, which are equally predaceous with the mature insect, the only distinguishable parts of the alimentary canal are the esophagus, a minute crop, a chylific ventricle, and a small gut—the ventricle being perfectly smooth externally. To what an extent this differs from the canal of the imago, will appear from a comparison with that of the common Tiger-beetle (*C. campestris*), formerly described, and figured on Plate 1st, fig. 2. Many instances of it being comparatively short in the early stages, are to be found in the same order, but in none is this more notable than among the phytophagous Lamellicorn beetles. That of the larva scarcely exceeds the length of the body, all the subordinate parts being absorbed (so to speak) by a capacious stomach filling nearly the whole of the splachnic cavity. This expansive ventricle, after the last metamorphosis, becomes narrow, its component

parts more distinctly defined, and so much elongated, that the whole digestive tube exceeds from six to twelve times the length of the body. The changes which it undergoes in the progressive developments of a Lepidopteron, (*Pontia Brassicæ*, the common cabbage-butterfly,) as traced by M. Herold,* are principally the following: In the Caterpillar there is a very short esophagus, with salivary vessels appended to it; an extremely large cylindrical stomach, and a short intestine, succeeded by a wide but short cæcum. Shortly after the chrysalis is formed, the esophagus is found to have become longer and more slender; the stomach to have decreased greatly, both in length and diameter, while the intestine is elongated, and the cæcum terminates in a pretty distinct rectum. As the chrysalis becomes older farther changes ensue, and about eight days from the time of its assuming that form, the sucking-stomach can be discerned, and the stomach begins to separate into two portions. These changes are more sensible when the butterfly is on the point of being disclosed, and after that event the esophagus is very long and slender; the sucking-stomach in the shape of a large vesicle; the stomach double; and the intestine very long and convoluted. Analogous changes take place in many other tribes, into the consideration of which we cannot now enter.

To what has been said respecting the anatomical features of the great alimentary organ, it may be ad-

* Entwickelung-Geschichte der Schmetterlinge, &c. 1 vol. 4to. Cassel und Marburg, 1815.

visable to add some further explanation relating to the physiological functions of its respective parts besides the incidental notices on this head already given. The food to be transmitted through its various chambers, if of a solid substance, undergoes a process of mastication by the oral instruments; but this process is not in all cases equally complete. Many predaceous kinds, particularly among the Coleoptera, masticate their food very imperfectly, merely dividing it into such pieces as admit of being swallowed. Further mastication is doubtless rendered unnecessary in their case by the presence of a gizzard where the trituration is afterwards perfected. Raptorious species destitute of the organ just named, (such as Dragon-flies) thoroughly comminute their food before swallowing it. Solid vegetable matters are of course always considerably reduced in the mouth; but those insects which feed on green leaves, particularly the caterpillars of Lepidoptera, swallow the small pieces they detach almost or entirely unchanged. In suctorial insects, as well as those which have been termed *Lappers* (the Stag-beetle is an example), mastication obviously becomes superfluous.

But it is not the mechanical action of the trophi (as the oral organs are sometimes called) alone that the food is subjected to in the mouth; it is here that it mingles with the secretions of the salivary vessels. These secretions consist of a whitish, frequently a purely hyaline fluid, said to be of an alkaline nature. The intermixture, to adopt Burmeister's words, has

a threefold purpose: 1*st*, The mechanical dilution of the nutriment; 2*d*, to exercise a chemical effect upon it; and 3*d*, a dynamical effect; or, in other words, to change the food into such a state that the requisite nutrimental substances can be separated from it. The chemical properties of the saliva have been but little investigated; that their action is powerful may be conjectured from the pain and inflammation produced by the puncture of a Culex or Tabanus, which is almost wholly occasioned by the saliva injected into the wound. The effect it has upon the leaves eaten by caterpillars is to make them almost immediately lose their colour, and assume a dirty brownish tint. Humboldt affirms that the saliva of serpents of itself suffices to change the flesh of recently killed animals into a gelatinous substance, and that it is for that reason they lick their prey all over before they swallow it. Burmeister is of opinion that it has a similar tendency in insects; at all events, there can be little doubt that its effects are not limited to a simple lubrication of the parts of the mouth, or a mechanical solution of the particles of the food.

After passing through the esophagial tube, the alimentary matter reaches the crop, where it remains for a time, and acquires a softer consistency by imbibing the peculiar juice with which this cavity is replenished. This juice is nearly transparent in herbivorous insects, but dark and fetid in the carnivora, as is often experienced by insect-collectors, for it is this matter which the animals so frequently dis-

gorge when handled. It is ejected by an antiperistaltic movement of the viscus. When the crop is succeeded by a gizzard, the food is soon urged, in small quantities at a time, into its opening, where it is subjected to the action of the teeth or horny ridges which cover its interior. The effect of this grinding process is so decisive, that it is in a short time reduced to a homogeneous pulp, which is called chyme. When the gizzard is wanting chymifaction takes place in the crop. But the chyme does not attain the highest degree of elaboration, till it has been for a time in the chylific ventricle. Here it generally assumes a deeper colour, and the chyle is separated from it. The latter is a thick liquid of a whitish, brown, or greenish colour, and is found under a microscope to consist of minute globules. Its production is the grand object to which all the previous processes tend, for it is the substance which forms the basis of all the nutritive fluids. An intermixture of bile has always been regarded as essential to its nature, and in the case of insects this ingredient has long been supposed to be supplied by what were formerly described as the bile-vessels. But several eminent physiologists have lately entertained some doubts on this subject, from observing that the so called biliary vessels empty themselves at a part of the canal *behind* the place where the chyle began to be absorbed; that their contents, when analysed, have little resemblance to gall, but consist in a great measure of uric acid; and that many insects have other secreting organs which empty them-

selves into the canal in front of the chylifying portion of it. In support of the older and more generally received opinion, that the function of these vessels is analogous to that of the liver, it is alleged, that by their insertion in the intestinal canal they correspond to the gall-secreting organs of other animals; that there is often a bladder-shaped distention where they join the canal, forming a kind of gall-bladder; that the vena porta which conducts the blood to the liver takes its rise from the fatty matter within the ventral cavity, as is the case with the vessels in question; and that the liver of closely allied animals (such as crabs, and annelides) consists likewise of such vascular appendages to the intestine.* Amid these conflicting sentiments, a mixed opinion best harmonises with the facts, and such has accordingly been adopted by Meckel, Tiedemann, J. Müller, and Burmeister; viz. that the vessels in question have a double function, sometimes secreting bile, at other times urine. Whether they secrete the one or the other probably depends on the point of their opening into the canal being within the region of the chylific ventricle, or posterior to it. In these circumstances, the name suggested by M. Audouin might be advantageously substituted for the present, for the most accurate knowledge we now possess of the functions of these vessels thus proves them to be *urino-biliary*.

The changes which the alimentary substances undergo in the part of the canal behind the insertion of the vessels just spoken of, depends in some

* Burmeister's Manual, p. 371.

measure on its length. When very short the chyme contained in it affords no chyle, as may be observed in caterpillars; but when of great length, there is no doubt that the chyme is further elaborated, and chyle separated, just as it was in the chylific ventricle. It is scarcely possible that the small egg-shaped ventricle of the Lepidoptera could separate all the chyle necessary for the support of life, unless aided by the long intestine; neither could we see any necessity for the elongated and often convoluted shape of the latter, if its only use was to convey the unassimilating parts of the food to the rectum.

The progressive advance of the alimentary bolus, which we have thus traced through the canal, is caused by a distinct peristaltic motion, as strong, considering the relative size of the animals, as among the vertebrata. This alternate contraction and expansion is most observable in the crop and gizzard, which are supplied with the strongest fasciculi of muscles, and gradually becomes fainter towards the anal extremity.

In the higher animals, it is scarcely necessary to remind the reader, the chyle is absorbed from the alimentary canal by the lymphatic vessels, and conveyed to the venous blood, with which it repairs to the lungs or gills in order to be oxydised. No such conduits as absorbent vessels or veins existing in insects, the chyle merely transudes through the parietes of the digestive tube into the cavity of the body whence it finds its way to a large cylindrical canal placed near the back, from which it receives an impulse which conveys it to different parts of the body

This leads to the consideration of the second great step in the process of nutrition, or what has been called

The Circulating System. Scarcely any point in the anatomy or physiology of insects has excited so much interest and attention as the movements of the nutritive fluid, and the nature of the organ by which its motions are produced. The most opposite opinions on the subject have been maintained by different observers, and it is only of late that evidence has been obtained of a sufficiently conclusive nature to establish the fact, that there is a translation of the blood, which virtually amounts to a kind of circulation, although it is very imperfect when compared with that of vertebral animals.

The organ which gives the impulse to this circulatory movement is named the *dorsal vessel.* It extends along the back from the head to the anus, lying only a short way beneath the integument, and consequently above the digestive canal, from which it is separated by a layer of fatty matter, (See Plate II. fig. 1. *a, a, a.*) When examined in a living insect, (it is best seen in a larva with a smooth transparent skin,) it is found to have a regular expansive and contractive motion, by means of which a fluctuating movement is communicated to the contained fluid. The whole organ, therefore, somewhat resembles an artery, although it is in fact the representative of the heart in this class of animals, and is frequently called by that name. In its general shape it is commonly more or less fusiform, widest in the abdomen, and diminishing towards the head. As it necessarily follows the contour of the body, it is

usually straightest in larvæ, (particularly in caterpillars,) and in the imago it curves downwards between the thorax and abdomen, to enable it to pass through the narrow isthmus by which these parts are united. On close examination it is found that the coats of this vessel are composed of two membranes, the exterior of which is dense and muscular. Such at least appeared their composition to Strauss, but Mr. Newport detected a third membrane of an extremely thin and delicate texture.

The greater portion of the vessel contained in the abdomen, consists of a consecutive series of chambers or cells, separated from each other either by single or double valvules, which permit the transmission of the blood from behind forwards, or in the direction of the head, but prevent its retrograde motion. "A little behind these valvules, on both sides of each chamber, there is a transverse opening, likewise having a semilunar valvule internally, which allows the blood to enter the organ and opposes its exit. The number of the cells varies according to the species, or rather the families. M. Strauss found eight in the Melolontha vulgaris, M. Burmeister five in the larva of Calosoma Sycophanta, while M. J. Müller discovered only one in Phasma; but in this he was probably mistaken. However this may be, the organization in question explains at once the progress of the blood in the dorsal vessel, and the reason of it being always filled. For when the hinder cell, which is usually shorter than the others, and which we shall suppose full of blood, contracts, the fluid, pressed on all sides by the containing vessel, is forced

to escape, and finds no other passage but that made for it in front by the yielding of the valvules which separate it from the second cell. Into this, therefore, it passes; but, at the same time, the preceding dilates, and the blood contained in the intestinal cavity presses against the lateral valvules, which yield and permit it thus to enter by the openings which they protected. The same process is repeated by the second cell, then by the third, and so on; the blood thus traverses them all by regular jerks, without any of them being ever left completely empty."*

This process will be better understood from an inspection of the annexed figures, after a drawing by Mr. Bowerbank, with his accompanying explanation.† Fig. 1st, *a, a,* represents two chambers of the dorsal vessel in their greatest state of collapse, when the point of the lower valve is seen closely compressed within the upper one. At the commencement of the expansion, the blood is seen flowing in from the lateral aper-

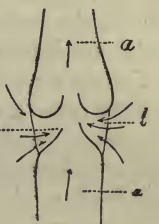


Fig. 2

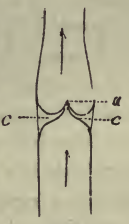


Fig. 1

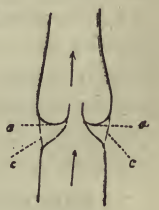


Fig. 3

* Lacord. Intro. II. 72. † See Entomol. Mag. I. Pl. II. 249.

tures, (fig. 2, *b*.) and, at the same time, the stream in the centre commences its ascent, as indicated in the drawing by arrows. When the chambers have attained their greatest state of expansion, the sides of the lower valve are forced upwards by the increased flow of the blood from the section below the valve, the lateral openings are closed, and the main current of the blood is projected through the two valves, as shewn in fig. 3, *a*.*

To each side of the abdominal portion of the dorsal vessel, or that which is divided into separate chambers furnished with valves, are attached several flat triangular muscles, the points of which are fixed to the dorsal plate of the abdomen, (Plate III. fig. 1, *h*.) These were called by Lyonnet, rather fancifully, the *wings of the heart*, and their object is to retain that organ in its place, and probably to aid its contractions and expansions. When of sufficient length, (as in the example figured,) they adhere immediately to the arch of the abdomen, but when short, their attachment is by means of a supplementary band of fibres.

As the part of the dorsal vessel, to which these remarks refer, is regarded as the true heart, so the anterior portion, which is a simple continuous tube, may be considered as representing the aorta. It commences where the valves and lateral muscles terminate, passes through the thorax, and terminates

* A section of the dorsal vessel is likewise shewn on Plate III. fig. 2, *a*, *a*, *a*, interior walls with their circular fibres; *b*, *b*, the lateral or auriculo-ventricular apertures; *c*, the semilunar valve; *d*, *d*, interventricular valves.

where the esophagus enters the mouth, either in a simple opening, in two or three branches, or in a numerous series of small ramifications. Its texture is more delicate than that of the propulsive portion of the organ, and it becomes gradually narrower as it approaches the head, (Plate III. fig. 1, *c*, *d*.)

The pulsations or alternate contractions and expansions of the dorsal vessel, in other words, the beating of the heart, vary greatly in number, within a given time, in different individuals, and even in the same individual, according to its stage of life and the temperature. It is most rapid in caterpillars, and slowest in the perfect insect. In the former, at an ordinary temperature, it has been observed to pulsate from thirty to forty-eight times in a minute; and when the heat was increased, the pulsations became so rapid and irregular that they could not be counted.

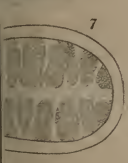
Much uncertainty still exists with regard to the manner in which the blood is conveyed to the different parts of the body after it is discharged from the heart. It is found to pervade the abdominal cavity, and to penetrate to all the extremities, without excepting the antennæ, legs, and wings. Distinct currents have been noticed in these members, apparently with a well defined course, but no blood-vessels can be said to have been any where detected. This extravascular motion of the blood is thought by some to be necessary to the adequate performance of the corporeal functions in insects, as the tunics of a vessel formed round it might interfere with the due deposition of oxygen. Nor, as Burmeister states, is the

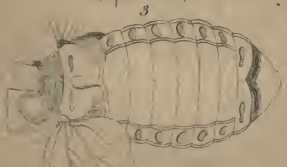
case without a parallel in the animal economy, for in the membranes of a developing embryo, the blood originally flows without vessels.

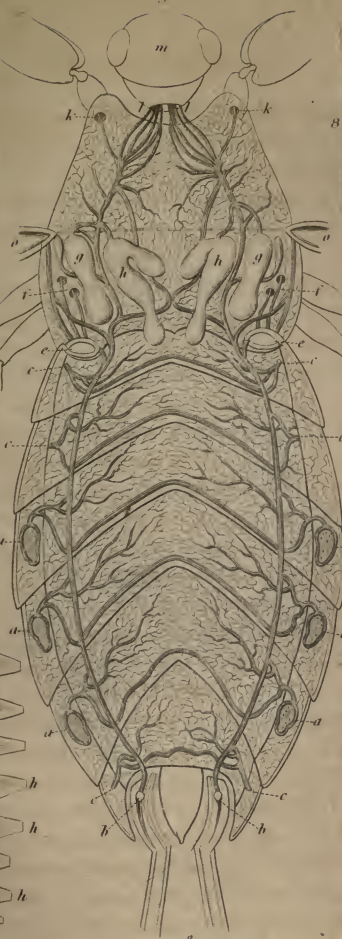
With regard to the blood itself, it generally appears quite colourless, or slightly tinged with green. Its motion can be discerned only by means of the globules which it contains, although these, also, are more or less transparent. The globules are very minute, but in this respect they vary much. Those of the caterpillar of the goat-moth are described by Lyonnet as three millions of times smaller than a grain of sand; while those of *Agrion Puella,* according to Carus, are larger than the globules of the human blood. Their general dimensions may be stated at from the 200th to the 250th part of a line in diameter.

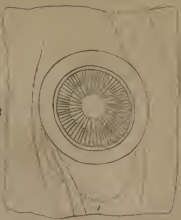
The mechanism of the dorsal vessel, and the manner in which it works, were first rightly understood by Dr. Carus of Dresden, who made his discoveries known to the public in 1826. Much additional light was shortly afterwards thrown on the subject by M. Strauss, in a work published at Paris in 1828.* The earlier anatomists had observed its pulsations, and investigated its structure with much care, but were unable to come to any satisfactory conclusion regarding its functions, chiefly from the circumstance of supposing it to have no opening in any part. Lyonnet conceived it to be designed for the purpose of secreting a substance for forming the nerves. Cuvier, also, after a pains-taking investigation, concluded that it

* *Considérations générales sur l' anatomie des animaux articulés, &c.*









CIRCULATING & RESPIRATORY ORGANS.

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was a secreting organ, although he did not determine the nature of the alleged secretion. Other opinions have been advanced on the subject; but probably M. Leon Dufour is the only eminent entomotomist, of the present day, who denies the existence of any kind of circulation in insects.*

Respiratory System.—The necessity for the blood being placed in communication with atmospheric air before it is adapted for assimilation with the organic mass, is as indispensable among insects as any other class of animals. We accordingly find an intricate and highly developed system of vessels, pervading, in a multitude of ramifications, every portion of their frame, in a manner very similar to the distribution of the blood-vessels in quadrupeds. The relations, indeed, between these two systems, as they subsist in the vertebrata, seem, as has been well remarked, to be completely reversed in the case of insects—in the former the blood is the moving and pervasive element —in the latter it is the air. The sanguineous fluid bathes almost every part of the cavity of the body; and being too languid to repair, with sufficient rapidity, to a given point to receive its vital principle, it is provided that the latter should be conveyed towards it; and this is done so effectually, that it can be imparted, with equal facility, wherever there is a molecule of the blood to be decarbonised.

The organs of respiration may be conveniently considered, as has been done by Kirby and Spence,

* Lacord. Intro. II. 69. *note* (3.)

under two heads, viz. the *external* organs by which the air is admitted into the body and expelled from it, and the *internal* ones by which it is distributed.

The former differ according as the place inhabited is land or water; in other words, according as the air is received directly, or through the medium of another element.

Nearly all insects inhabiting the land and the air, as well as the amphibious species (*Dytiscidæ, &c.*), receive their supply immediately from the atmosphere which surrounds them on all sides, and it is admitted by apertures named spiracles or stigmata. These are small perforations, commonly of an oval or rounded form, placed along the lateral margins of the body. In number, and almost every other respect, they vary greatly, but their arrangement is always symmetrical, one on the right side, and another on the left; each segment, for the most part, being thus furnished with a pair. (Pl. III. fig. 3.) They never exist in the head, and there are never more than two pair in the thorax, consequently the greater number are to be found in the abdomen. They are usually surrounded by a horny ring, and their aperture can be closed at the will of the insect by means of a muscular apparatus. To enable it to do this more effectually, the mouth is sometimes furnished with plates which close like shutters, or it is fringed with hairs, ciliæ, &c. Two of their most simple forms are represented on Plate III. figs. 4 & 5. A more complicated structure is exhibited by the hinder stigmata of *Dytiscus marginalis*, (Pl. III.

fig. 6,) which appear when open, like a membrane torn longitudinally not far from one of the sides, leaving jagged and deeply divided edges, beset with pencils of hair. In other cases the aperture is filled by a cellular membrane drilled with small holes for the passage of the air, as in the common cockchaffer, (Pl. III. fig. 7). In the larva of the water-beetle mentioned a few lines above, a circular membrane is stretched over the valves, ornamented with concentric zones of different colours, and having a circular aperture in the centre, (Pl. III. fig. 8.) Other peculiarities presented by these pneumatic orifices are to be found in species belonging to the different orders.

Many aquatic insects have a special provision for introducing the air more readily into their system, which is rendered necessary by the difficulty they would experience in bringing their spiracles into contact with it. This generally consists of an elongated anal tube, sometimes naked at the extremity, but more frequently surrounded with hairs or branched rays, often exhibiting a very beautiful radiated appearance. It is pushed upwards to the surface while the body of the insect continues submerged, and admits the air at its extremity, an operation much facilitated by the rays alluded to, which have the power of repelling water, and diverge on all sides, thus leaving a free space for the influx of the air. Appendages of this nature are chiefly found among the Diptera, and will, therefore, be further noticed in describing that order. A common species of another order, *Nepa cinerea*, possesses two respir-

atory tubes, which were not properly understood till explained by M. Leon Dufour. Externally they have the appearance of an ovipositor, and have often been mistaken for such, although they exist in both sexes. Each is composed of two pieces, grooved internally, and meeting each other very closely at the edges, thus forming an elongated siphon, which introduces the air to two spiracles placed at the termination of the two principal air-tubes running along each side of the body. In this and analogous instances, the other spiracles have become obsolete, their functions being superseded by another kind of mechanism.

In the cases hitherto alluded to, whether relating to terrestrial or aquatic insects, the pneumatic mechanism is adapted for the admission of air from the atmosphere; it is next to be considered as fitted to separate and imbibe the air which is mechanically mixed with water. The species possessed of such an apparatus are as exclusively aquatic as fishes, and the apparatus itself is quite analogous to the respiratory mechanism of these animals. The *Gills* or *Branchiæ* are processes of the epidermis, projecting from the body in various forms, commonly resembling hairs or leaves, and completely filled with delicate tracheæ. The exterior membrane is so fine as to allow these to be seen through it. The manner in which the air is extracted by their means is founded on the following law of organic chemistry, recently discovered by M. Dutrochet. If we enclose a liquid or a gas in a cavity with permeable coats, a bladder for example, and plunge this bladder into another liquid or gas

of a different nature or density, two contrary currents are established through the sides of the bladder, the one conveying the liquid from without into the latter, and the other having an opposite effect. Gases, besides, have this peculiarity, that if we enclose a mixture, in certain proportions, of oxygen, carbonic acid, and azote, and plunge the bladder containing it in water having air in solution, the two currents established in the manner mentioned, continŭe till there remain in the bladder only oxygen and azote in the proportions which constitute atmospheric air.

"This double phenomenon takes place equally well through a living organic tissue and an apparatus employed for experiment. Accordingly, it is easy to perceive, that if some of the air-tubes of an insect were to become external to its body, and floating in the water, the carbonic acid which they contain after the blood has been decarbonised, will escape through their walls, and be replaced by the oxygen of the air which is mingled with the water. This, in fact, is exactly what takes place with branchiæ, which are nothing else than tracheæ closed at the extremity, and contained in a membrane remarkably permeable. These tubes extract the oxygen from the water, rejecting at the same time the carbonic acid they contain; and the air enclosed in the interior tracheæ, thus become fit for the support of life, acts in the same manner as in aërial insects."*

Branchiæ are not known to exist in any insect

* Lacord. Intro. à l' Ent. II. 91.

after it has reached its perfect state; nor in pupæ, except among the Diptera; but they are found in the larvæ of all the orders, except the Orthoptera, Hymenoptera, and Hemiptera. They are either in the form of approximating fasciculi of hairs, or broad thin plates, variously lobed and divided on the edges. The former are most common, and may be witnessed in the larvæ and pupæ of common gnats; the latter in the larvæ of whirlwigs (*Gyrinus*), Ephemeræ, Phryganidæ, &c. In Dragon-flies, the small leaf-like tracheal plates are placed in the cæcum, where water is alternately admitted and ejected, serving the double purpose of supplying the air-pipes and aiding locomotion.

These appendages are usually kept in a state of continual and intense agitation, probably for the purpose of always bringing around them a new supply of fresh air. When placed in expanded plates along the margins, their continual undulating motion must assist materially in maintaining the equilibrium of the body and facilitating movement in the water.

When the air has found admission into the body of the insect by one or other of the various avenues above described, it is received by the

Tracheæ or Air-tubes.—These are ramose tubes, opening into a spiracle, or originating from a branchia, and spreading through all parts of the body. As no insect can exist without air, and as these are the only channels by which it can be distributed, they are in no case deficient or imperfectly developed. The manner of their distribution is so varied as to pre-

clude the attempt to describe it in every particular case; but the normal or prevailing arrangement is nearly the following:—All the minute internal ramifications converge into several trunks, which gradually become wider till they debut on a spiracle. Tracing the course of these trunks upwards from the spiracle, they are generally found to divide into two principal branches, one of them becoming ramified *ad infinitum*, the other of a more uniform diameter and running across to unite with a similar one from the opposite side. A more complete union, however, is established among all the principal branches, by two longitudinal trunks extending the whole length of the body, one on each side, not far from the margin and parallel with it. These are nearly of the same diameter throughout, and intersect the transverse branches not far from their origin. This continual anastomosis provides for the utmost freedom of conveyance in every direction, and places the stigmata on opposite sides of the body in direct communication with each other. In addition to these there is sometimes a longitudinal tube in the centre, and in certain instances there are not fewer than five or six running lengthwise. Some of the principal longitudinal tubes give off branches to the legs, and a considerable number enter the cavity of the head.* Although the tracheæ

* To illustrate the distribution of the air-vessels, we have given a figure of those of *Nepa cinerea* after M. Léon Dufour. See Pl. III. fig. 9, in which *a*, *a*, *a*, represent the lateral spiracles, in this instance obsolete, because the air is admitted by terminal tubes; *b*, *b*, ventral spiracles, at the base of the

on different sides of the body generally communicate with each other in the manner indicated, there are not wanting instances where such a union cannot be traced. This, according to M. Léon Dufour, is the case with the majority of the Hemiptera, the respiratory arbuscles on the one side appearing quite independent of those on the other.

On examining the structure of the tracheal tubes, we observe, first, an outer membrane, smooth and transparent, and seemingly without fibres; then a very delicate cartilaginous filament of a pearly white colour, twined spirally round, and forming a tube like the windpipe of the superior animals, within which there is a thin membrane adhering closely to the spiral filament. The outer membrane is commonly colourless, but occasionally it is brown, red, or black, and, in such cases, the ramifications of the vessels can be followed more easily. The pearl-coloured filament, also, in recently dead specimens, affords a similar advantage, as it makes the vessels shine, while the air continues in them, like branches of arborescent silver.

Besides the tubular tracheæ, others are occasionally to be met with of an entirely different character, which have received the name of *vesicular air-vessels.*

anal tubes; *c*, *c*, *c*, trunks closed at their extremity; *e*, a bladder-like bag, receiving a branch from the longitudinal trachea; *f*, *f*, *f*, tracheæ designed to supply the tegmina, wings, and four posterior legs; *g*, *g*, *h*, *h*, tracheal bags belonging to the thorax; *k*, *k*, tracheæ of the anterior legs; *l*, *l*, tracheæ to supply the head; *m*, part of the head; *o*, base of the tegmina.

These are, properly, only distended tubes, assuming the form of pneumatic bags, inflating when the air is admitted to them, and becoming flaccid when it is withdrawn; they are to be found in nearly all the orders, but are most numerous and conspicuous among the Orthoptera. In *Truxalis nasutus* no fewer than twenty exist in the abdomen, of an ovoid shape, and lying transversely, ten on each side. They are so much developed in certain Diptera, (*Syrphidæ*, *Tabanidæ*, &c.) as to make the abdomen appear transparent, and as it were vitreous. Their principal use is probably to diminish the specific gravity of the body, and thereby increase the power of flight; at all events they will be attended with this effect, and they have, in fact, been chiefly observed in the species which are longest and most frequently on the wing. When the tracheæ, instead of ramifying in the usual manner, interlace each other, and unite into matted bundles, as they have been observed to do in certain Coleoptera and Hemiptera, they form what have been termed by Léon Dufour *parenchymatous tracheæ*. In Nepa these are oblong bodies, placed immediately beneath the scutellum, (Pl. III. fig. 9, *g*, *g*,) free in the middle and fixed only at the ends, and may almost be supposed, when taken in connection with some accessory parts, to be a faint representation of an incipient pulmonary organ.

The indefatigable Lyonnet has had the patience to count the tracheal branchlets of the caterpillar of the Cossus, and he detected 236 longitudinal ones, 1336 transverse, and 232 detached, so that the body of

that insect is permeated by 1804 aëriferous tubes large enough to be visible, and it is probable that an equal number exist so small as to elude the sight, even when assisted by the most powerful glasses. "Surprising as this number may appear, it is not greater than we may readily conceive to be necessary for communicating with so many different parts; for, like the arterial and venous trees which convey and return the blood to and from every part of the body in vertebrate animals, the bronchiæ, (that is, the smaller ramifications of the tracheæ,) are not only carried along the intestines and spinal marrow, each ganglion of which they penetrate and fill, but they are distributed also to the skin and every organ of the body, entering and traversing the legs and wings, the eyes, the antennæ, and palpi, and accompanying the most minute nerves through their whole course. How essential to the existence of the animal must the element be that is thus anxiously conveyed, by a thousand channels so exquisitely formed, to every minute part and portion of it! Upon considering this wonderful apparatus, we may well exclaim, *This hath* God *wrought, and this is the work of his hands.*"

Adipose tissue, and Secretions. Although the former of these is not in immediate connection with any one organ more than another, but fills the splachnic cavity wherever it is not occupied by other substances; yet it so far bears a relation to the function of digestion and the nutritive organs, that it

* Kirby and Spence's Introd. IV. 65.

may without impropriety be noticed in this place. It consists of a reticulated web, of a white or yellow colour, the shreds of which, when examined by the microscope, are found to be constituted by small globules of animal matter. It is more or less compact in different insects, and even in the same insect according to its age, being loosest and most stringy in young individuals. It very nearly corresponds to the fat of the larger animals, but as chemical analysis has produced different results, its essential properties and uses cannot be considered always the same. Virtually, however, its uses may be regarded as twofold; first, to protect the various organs by forming a soft and elastic bed, which retains them in their place, and prevents them coming in too close contact with each other; secondly, to afford a certain degree of nutriment when the insect is not in a condition to receive food. In the latter case, it exactly corresponds to the store of fat found in hybernating mammalia, when they go into their winter quarters. It is particularly plentiful in the caterpillars of the Lepidoptera; as they go through their various metamorphoses it gradually becomes more scanty, till it almost entirely disappears in the mature fly. It is hence naturally inferred that it supplies the requisite nutriment during the pupal sleep, and is gradually absorbed to aid in the development of the newly formed parts. Next to caterpillars it is most abundant in Coleoptera, Orthoptera, Hemiptera, and Neuroptera; or, speaking generally, it is more plentiful in masticating than sucking insects. Some dis-

tinguished Physiologists maintain that the fatty mass is analogous to the liver; but its structure, alternate increase and decrease, and the presence elsewhere of what may, in certain cases, be considered as true biliary vessels, appear sufficient reasons for rejecting this opinion.

Certain secretions having a direct influence on digestion have already claimed our notice while considering that function; but there are others, which may be regarded as the produce of digestion, since extracted from the blood, to which we have yet to refer; and their importance will be judged of when it is mentioned, that it is almost entirely from them that we derive all the insect products which we have converted to our own use. Of these *Silk* may well be regarded as the most valuable, since it has become nearly as essential to our own purposes, as it is to the economy of the animals which produce it. The vessels which secrete it resemble the biliary vessels in shape, but are usually much larger, (in the silk-worm they are about a foot in length,) consisting of two tubes, which unite at the extremity, and open into a small perforated filiform organ, commonly placed between the palpi on the under lip. This is named the *spinneret*, and the size of its aperture determines the thickness of the thread. The fluid, before it comes in contact with the air, is viscous and transparent in young larvæ, but thick and opaque in mature ones. It is found by chemical analysis to be chiefly composed of a gummy matter, a small portion of another substance resembling wax,

and a little coloured oil. It may be placed in boiling water without undergoing any change; the most highly concentrated acids are required to dissolve it. Except in one instance, (the female of the great aquatic beetle, *Hydrous piceus*,) this secretion is found only in larvæ, and in these the spinneret is usually situate in the mouth; but in the larvæ of *Myrmelion* it is in the opposite extremity of the body, like the spinning apparatus of spiders. This is likewise its position in the beetle just alluded to.

To the secretion of *poison*, and the beautifully constructed instrument by which it is injected into the body of an enemy, insects are indebted for one of the most effectual means of defence which has been assigned to any kind of animal. It is limited to the Hymenoptera, and among these we are most familiar with its effects in bees and wasps. The poison is contained in a round or ovate bladder, lying very near the hinder extremity of the abdomen, and is discharged into the sting by a narrow duct. It is secreted by two very slender twisted vessels, which sometimes unite (as in the hive-bee, *Apis mellifica*,) into one tube at a little distance from their insertion into the bladder. The fluid is sharp and corrosive, and it is unnecessary to refer to the experiments of Reaumur to prove that it is the cause of the inflammation and pain attending a puncture of the sting. The mere mechanical division of the tissues by so fine a point, would occasion comparatively little of either, as may be ascertained by making a puncture in the hand with a needle. The venom is a trans-

parent fluid, of a sweetish taste when first applied to the tongue, but speedily producing a sharp burning sensation. Its chemical properties have not been properly examined; but according to Fontana, it is soluble in water, and when alcohol is added to the solution, it is precipitated in the form of a white powder, which converts vegetable blue into red. Its action is so powerful, that the writer just named calculates that a grain in weight would kill a pigeon in a few seconds.

Allied to the preceding, are the *acid* secretions of ants and a few other insects, which, however, have not been traced to any special secreting organ, but seem to be diffused throughout the system. Vaquelin and Fourcroy conceived the former to be composed of acetic and malic acid, but Suensen has recently demonstrated that the earlier chemists were correct in regarding it as of a peculiar nature, and that the name *Formic acid* ought therefore to be retained. Berzelius gives the following analysis of it; hydrogen, 2, 84; carbon, 32, 40; oxygen, 67, 76. It is sometimes ejected by the anus; and Lacordaire affirms, that in tropical countries ants are to be met with (*Gen. Ponera*) armed with stings, which inflict as painful a wound as those of bees. Gallic acid has been obtained from the grain weevil, (*Calandra granaria*) and what has been named bombic acid from the silk-worm. It is probably one of these that is employed by certain Lepidoptera to loosen the end of their cocoons, when they wish to obtain egress.

In the absence of special secreting vessels, the

function is sometimes executed by the articulating membrane of the abdomen and limbs. Thus the *wax,* which is secreted by the neuters of the common hive-bee, is elaborated by the delicate membrane which passes from the superior half of each ventral segment, and after describing an arch, unites itself to the preceding. The orange-coloured *oil* which exudes from the oil-beetle, (*Melöe Proscarabaeus,*) is secreted by the membrane which connects the thigh with the tibia; and examples of a similar nature are not of unfrequent occurrence. The white filamentous or cottonny substance which covers the body of many aphides, is probably of the same nature as wax, as well as the peculiar efflorescence observable on many coleoptera. The latter often forms regular designs on the surface, (as in *Lixus, Cleonus, Eurychora,*) which can only arise from a particular disposition of the pores through which the substance obtains a passage.

Lac, a substance of well-known utility in the arts, as entering into the composition of varnish, sealing-wax, &c., is the glutinous and semitransparent transudation of the *Coccus lacca,* which envelopes its whole body after it has fixed itself to the branch of a tree, according to the manner of its congeners.

An endless variety of *scents* are emitted by insects, some of which emanate from the fluids already alluded to, while others transpire in the form of invisible effluvia, from all parts of the body. Many of them are highly penetrating and diffusive, so that they can be felt at a considerable distance. Some of them are

extremely disagreeable, but others are of an opposite description. In all cases, they probably serve more or less as a means of defence; for it is likely that even those which are agreeable to our sensations, may prove repulsive to some kinds of enemies. This is rendered the more probable by the emission of these odours (except in a few instances) not being involuntary, but under the direct control of the individual, and they are seldom exhaled in great strength, in many cases not at all, except when it is disturbed. They appear also to serve as a guide to the sexes in discovering the place of each other's retreat. The Coleoptera and Hemiptera afford the most remarkable instances of this property, and the latter have been ascertained by M. Léon Dufour to possess a special odoriferous organ. It is a purse-shaped bag, placed at the base of the abdomen, immediately beneath the viscera of digestion, secreting an oily fluid, which volatilises in the form of an invisible vapour, and escapes by pores in the sides of the metathorax, between the insertion of the middle and hinder legs.

The only other substance which requires to be noticed under the head of secretions, is that very remarkable one which renders many kinds of insects luminous. It is not elaborated, however, by any set of vessels appropriated to the purpose, but consists of a minutely granular mass, analogous to the adipose tissue; yellowish white, semitransparent, and completely filled with tracheæ. The investigations of M. Macaire show that this matter is essentially com-

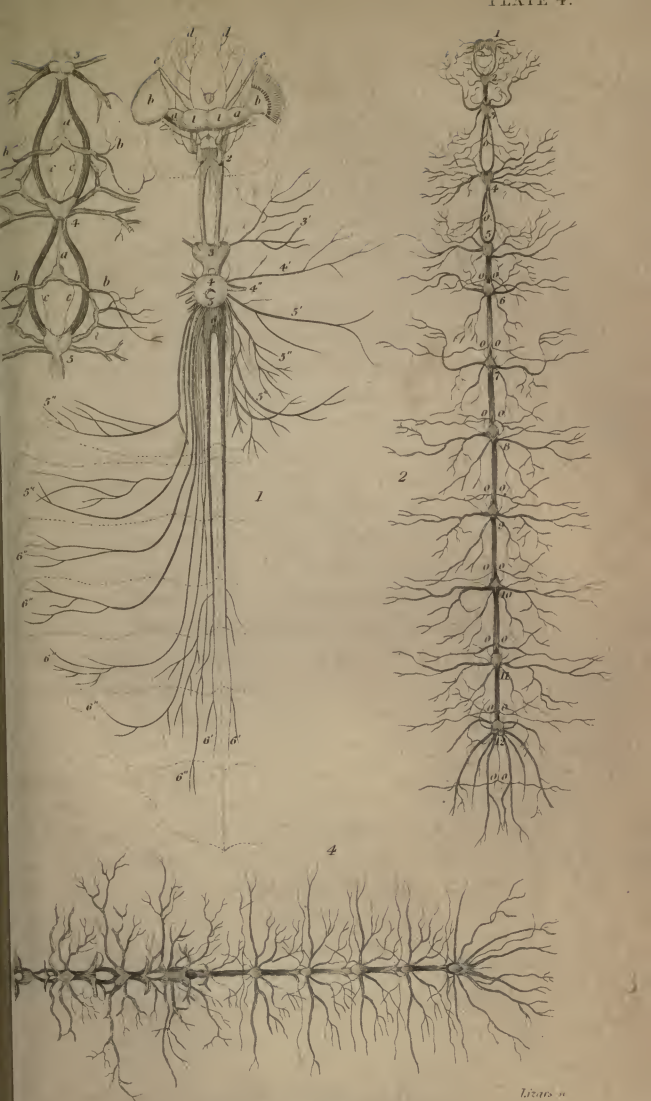
posed of albumen. But as albumen is not luminous of itself, it must be combined with a certain proportion of phosphorus, in order to produce the phenomenon in question. "As phosphorus can only become luminous by contact with oxygen, if we imagine it combined with the fatty substance, or with its albumen, respiration gives it luminousness; by means of respiration, oxygen is deposited in the corporeal substance, and each respiration therefore makes the beetle shine. Now, respiration being strongest during flight, it necessarily follows, that the emission of light will also then be most powerful. In opposition to this, the wingless state of the female might be urged, yet her short thicker body must contain more of the fatty substance, and must therefore emit a stronger light than that of the male. Next to respiration, the circulation of the blood appears to have considerable influence upon the light, for we know that the substance emits the light only when moist. As now, the blood flows all round upon the fatty substance, this may be considered as the moisture, which helps to support the luminousness. Carus has also observed that upon each pulsation, and consequently upon each fresh wave of blood, the light shines brighter. He refers to this, also, the brighter shining of the female, as she constantly dwells in dark damp places. Thirdly, the nervous system may exercise a certain influence upon the production of the light; for as it is the chief agent of all the voluntary actions of the body, it will also necessarily exercise an influence upon the voluntary suppression of the light, if the insect stop this

influence by checking respiration in the way in which it causes the nerve to act upon the muscle in muscular motion."*

These remarks appear to harmonise with the principal facts which have been ascertained respecting this interesting phenomenon, and the nature of the substance by which it is produced. These facts are chiefly the following:—the light is subject to the will of the animal; it becomes more brilliant when its motions are violent; a certain degree of heat is necessary for its display, and its intensity increases up to 40° R. when it becomes extinct, as it likewise does when the cold is at 10° R.; oxygen renders it more brilliant for a short time, but soon extinguishes it; the same effect is produced more speedily by irrespirable gases, and by placing it in a vacuum; the phosphorescence soon disappears after the death of the animal, but can be restored by warm water, oil, or alcohol; galvanic electricity excites it; and, finally, when the insect is kept for some time in the dark, the luminosity disappears, but is restored by exposure to the light of the sun.

According to the observations of M. Morren, professor of botany in the University of Liege, as detailed by Lacordaire, the luminosity of the common European Lampyridæ is increased in brilliancy by the peculiar structure of the corneous envelope of the phosphorescent matter. It is stated to be merely a continuation of the general tegument, become much

* Burmeister's Manual of Ent. p. 497.



NERVOUS SYSTEM.

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attenuated and capable of being raised like a thin plate. "Its exterior face presents a net-work of hexagonal meshes, resembling that of the epidermis of plants. Each hexagon is convex, and has a conical hair in its centre, directed backwards. The rest of the surface is simply covered with small asperities, and the opposite or inferior face is concave and smooth. Each of the luminous points is thus composed of a multitude of facets, and forms an apparatus entirely similar to that which Fresnel has invented for the diffusion of light, and which bears his name. When this corneous cap is removed, the luminous matter loses a great part of its brilliancy. Every thing, in other respects, is managed with a view to increase the light to the utmost. The largest and most regular facets occupy the centre, and the smaller ones are placed at the sides, regularly decreasing in size. The hairs tend to prevent the dust settling, and the larva is possessed of a kind of anal brush, which it can employ in cleaning them."*

The phenomenon in question is almost confined to the Coleoptera, and among these to the families Elateridæ and Lampyridæ. About thirty luminous species of the former are known, and nearly 200 of the latter, four of which are indigenous to Europe.†

Nervous System.—The important and singular department of the animal economy now to be briefly considered, is rather of a simple nature in insects,

* Lacord. Intro. à l' Ent. II. 147.

† Examples of both will be found figured and described in our Coleopterous Vol. p. 161-172.

that is, in its external and material properties, for the manner in which it obeys the commands of the governing principle is just as subtle and mysterious in this as in any other branch of the animal kingdom. As the seat of sensation, it is the originating and animating cause of all activity and motion in the various organs. To it the senses convey their intimations of the different properties of external things, of which they are respectively adapted to take cognizance. From it the muscles derive the irritability which puts them in action; by means of the nerves the intestinal canal is excited to action, and, by the impulse of the same organs, the sexual parts exercise the function appointed to them.*

The nervous cords, on which such important duties are devolved, are composed, like those of mammals, of exceedingly minute globules, disposed in linear series, so as to form fibres of extreme tenuity. This matter constitutes the central nervous mass, pulp, or medullary matter, and it is contained within a darker-coloured cortical layer, exterior to which there is an envelope of a fibrous nature, rather thick, and formed of two tunics, analogous to the dura-mater and the pia-mater.

In regard to general form, the nervous system is disposed in a double cord running along the whole length of the body, which forms knots or ganglions at certain intervals, corresponding, in many cases, to the number of segments. These ganglia send forth

* Burmeister's Manual, p. 474.

nerves in pairs, which visit all the principal organs, and ramify in all directions.

The nervous system may be considered under two divisions, the ganglionic central cord, with its branches, and the nervous system of the esophagus and stomach. The former is the analogue of the spinal marrow, and the latter of the great sympathetic nerve.

The ganglionic cord extends from the head to the hinder extremity, is situate beneath the intestinal canal, and runs along the ventral face of the body; (Pl. II. fig. 1, *g*, *h*, *i*, *l*, *l*.) This presents knotty expansions or ganglia at intervals throughout its whole course. Two of these are placed in the head, one above the esophagus near the pharynx, the other beneath it, and, considered collectively, they form what many authors have denominated the brain, (cerebrum and cerebellum of Burmeister.) The anterior of these cephalic ganglia, (the cerebrum,) lies transversely, and is usually more or less distinctly divided into two hemispheres. It emits a nerve to each of the antennæ, also the optic nerves, and lateral branches which unite it to the posterior cephalic ganglion. The optic nerves spring from the outer margin of each cerebral lobe, and are generally broad at the base and narrower at the extremity terminating in the eye. Their base is sometimes as wide as the lobes themselves, and in certain cases they are broader at the extremity than any part of the cranial ganglion. The optic nerves of the stemmata likewise originate from the same source, sometimes in single filaments, at other times divided near the extremity. After the

optic nerves, which are the largest in the whole body. the most considerable are the lateral cords uniting the two ganglia in question; their length is in proportion to the diameter of the esophagus, and as that is least in sucking insects, the two ganglia in these approximate almost to touching, but they are remote in gnawing species, and the uniting nerves are proportionately elongated.

The sub-esophagial ganglion (the cerebellum of Burmeister, or rather what is called the *medulla oblonga* by Mr. Newport, who regards the true analogue of the cerebellum to be entirely wanting in insects,) is commonly heart-shaped, or inclining to transversal, and lies at the base of the cavity of the skull. Anteriorly it gives birth to several nervous stems on each side, which supply branches to the mandibles, maxillæ, labium, and the neighbouring muscles; and, posteriorly, it gives origin to the long nerves which form the ventral chain.

The latter is composed of either one or two equal nervous cords, and the maximum of ganglia which it contains is eleven, in which case one is allotted to each segment. Frequently, however, they are concentrated in the thorax, and the abdomen entirely deprived of them. The mode of their distribution is most regular in larvæ. Each of them sends off nervous filaments, commonly amounting to three pair on each side; those in the thorax supply the wings and legs, those of the abdomen the muscles with which its cavity is furnished, and the hinder abdominal one transmits branches to the organs of generation. When ganglia do not exist

in the abdomen, the nerves descend in long threads from the thoracic knots.

Mr. Newport, following up a discovery of Lyonnet's, has lately made us acquainted with a delicate system of nervous branches appropriated to the respiratory organs, which lies above the ventral chain, following it without interruption through its whole extent. It consists of a very slender thread placed on the median line of the longitudinal cords, but not easily distinguishable except where these are separated; it then seems to spring from the inferior angle of each ganglion, although, in reality, it passes above it. At a little distance from that point it divides into two branches, which extend laterally in opposite directions. No knotty expansion is visible in caterpillars, but in Carabus and Gryllus there is a distinct one at each dichotomous division of the filet, especially in the thorax, where these nerves are most highly developed. As the changes which they undergo in the course of metamorphoses do not correspond to those that take place in the ventral chain, which always tends, with every successive development, to a higher state of concentration, Mr. Newport regards these nerves as forming a separate system, and he has named them the auxiliary, transverse, or respiratory nerves.*

The preceding descriptions will be better understood by the illustrative figures on Plate IV. Fig. 1 represents the nervous tree of the common cockchafer, which may be regarded as the type of that division

* Philosophical Transactions for 1832–4.

of the Coleoptera destitute of abdominal ganglia ; 1, 1, lobes of the anterior or cerebral ganglion ; *a, a,* optic nerves ; *b, b,* eyes : 2, posterior cephalic ganglion ; 3, prothoracic ganglion, emitting two pair of nerves on each side, 3′; 4, mesothoracic ganglion, sending off two pair of nerves, one, 4′, for the wings, the other 4″, for the middle legs ; 5, metathoracic ganglion furnishing four pair of nerves, the anterior, 5′, for the hinder legs, the others, 5″, for the first segments of the abdomen ; 6, ganglion representing the ordinary abdominal series ; besides the two medullary cords, 6′ 6′, which run in a straight line to the extremity of the body, it sends out on each side five pair, 6″, distributed among the fourth, fifth, sixth, seventh, and eighth abdominal segments ; *d, d,* mandibular nerves ; *e, e* nerves of the antennæ.

Fig. 2, nervous system of the caterpillar of Sphinx Ligustri, a few days before becoming a chrysalis. 1, cerebral ganglion, 2, posterior do., 3, 4, 5, 6, thoracic ganglia, 7, 8, 9, 10, 11, 12, abdominal ganglia, *o, o, o,* system of transverse nerves, more distinctly seen in fig. 3, in which 3, 4, 5, represent the three thoracic ganglia, *a, a,* central nervous filet, *b, b, b, b,* nerves furnished by this filet, *c, c, c, c,* nervous threads separating from the preceding nerves and which, by uniting when they reach the ganglion constitute the central thread.

Fig. 4 is a delineation of the nervous system in the chrysalis of Sphinx Ligustri, thirty days after its change, showing the much greater state of concentration it has already attained. The posterior thor-

acic ganglia are nearly united into one mass; and all the nerves furnished by these ganglia to the locomotive organs, will be seen to have acquired a considerable development.

The *sympathetic nervous system* has been known from the time of Swammerdam, who discovered it in the larva of the rhinoceros-beetle (*Oryctes Nasicornis,*) but its real nature, and the analogy it bears to the great sympathetic nerve of the vertebrata, were not understood till it was made the subject of a special investigation by John Müller.* It exists more or less distinctly in all articulated animals, but in none is it so complete as in insects. It is considered as forming two divisions; one of them consisting of a single cord, running along the anterior portion of the alimentary canal, and emitting delicate filaments on each side; the other of a double nervous web, originating on each side by one branch from the posterior portion of the anterior cephalic ganglion, running down the esophagus, and sending forth branches to the single nervous cord. Both these divisions stand in the most intimate relation to each other, and form one continuous system. The first is most conspicuous in Coleoptera, Neuroptera, and Lepidoptera. In these it takes its rise in two arched branches from the anterior cephalic ganglion, which unite in the centre and form a small knot, from which a single nerve emanates and runs beneath the cerebrum. From its curved shape, this was called by

* Nova Acta Phys. Med. Soc. XIV. part 1, p. 73.

Swammerdam and Cuvier the *recurrent nerve*. The double nervous web preponderates in the Orthoptera, and especially in Locusta and Gryllus.

The remarkable and characteristic attribute of this system is, that it is in no degree influenced by the changes which the ventral system undergoes in the different stages of metamorphosis. It is quite as fully developed in the young larva as in the perfect insect and *vice versa*. It may be thence naturally inferred that its functional uses are required at the earliest stage of life; and this in reality is the case, for it is destined to preside over the functions of what has been called vegetative life, which reach their highest pitch of activity in larvæ.

As the nerves constitute the fundamental organs of all sensation, this is the proper place to speak of the *senses*, the avenues through which the properties of external objects are conveyed to them. Judging partly from their structure, and partly from the actions that follow certain impressions received from without, we are inevitably led to infer, that insects possess at least all the senses which exist in the higher animals, some of them even in a greater state of perfection. Nay, it is by no means improbable that additional ones have been assigned them, to which we have nothing analogous in our own system, and of which, therefore, we cannot form any accurate conception. It is even a matter of doubt what organs are to be regarded as the seat of certain senses, the existence of which we are scarcely authorised to call in question.

Touch is the sense most generally diffused over the bodies of the higher animals, and it seems equally dispersed among insects; but the hard covering of the latter must often render it very obtuse, except in particular places. In the soft bodies of many larvæ, it is true, the skin is so delicate that it may well be susceptible of the finest impressions, and capable of transmitting the most vivid sensations; this power, besides, is often greatly aided, in such cases, by the hairs usually scattered over the surface. But though the rigid covering may often produce comparative insensibility, or merely give indication of the presence of bodies, this sense is always so concentrated in certain organs as to intimate the properties of material objects, such as form, size, density, &c. The organs in which it is most perfect are undoubtedly the palpi. Their articulated structure adapts them for being closely applied to bodies; the delicate membrane which often covers their extremity is particularly fitted for receiving impressions; they are supplied with a considerable nervous branch; and they are observed to be continually applied by the insect to the objects with which it comes in contact. At the same time there can be little doubt that the same function is performed more or less perfectly by other parts, such as the tarsi, the spiral proboscis of Lepidoptera, the haustellum of Diptera, and in most tribes more especially by the antennæ. Whoever has watched the antennæ of a hive-bee, an ant, or an ichneumon, when engaged in any operation in which it is interested, will be surprised that ever it could be doubted

that this is one of the uses to which they are eminently subservient.

Still, however, touch is only a secondary function of the latter; the generality of authors now agree in regarding them as the appropriate organs of *hearing*. When a beetle with long antennæ is suddenly surprised by a loud sound, it stretches these members outwards and holds them immoveable as if listening, and moves them carelessly again when the noise has ceased. They are two in number, in this, as well as in their prominent situation, corresponding to the ears of the vertebrata. On close examination a soft articulating membrane can be detected at their base, beneath which the antennal nerve is conducted; this may be considered as the last vestige of a tympanum, and the nerve alluded to, as an acoustic nerve. Viewed in this light, the stalk of the antennæ must be employed to collect the pulses or vibrations of the atmosphere and transmit them to the sensorium, an office for which their branched, plumose, and other delicate structures all tending to increase the extent of their surface, eminently fit them. This view receives strong confirmation from the circumstance of the auditory organ of the crustacea being placed at the base of the antennæ, sometimes even in the radical joint. It has been well observed also that the organs in question are almost always very fully developed in such insects as emit sounds as a signal call to the sexes a case in which hearing requires to be more than usually acute. Crickets, Grylli, and Cerambycidæ, may be given as

instances of this. When to all these we add the negative consideration, that the antennæ are strangers to taste and smell, and subservient to touch only in a secondary degree, no alternative seems left but to regard them as organs of hearing.

It may be proper, however, to add, that Latreille considered the seat of this sense to be two small apertures which he detected near the inner edge of the eye in Lepidoptera; M. de Blainville, two openings in the posterior part of the head, visible in Cicada; M. J. Müller, two cavities in the dorsal portion of the metathorax, which he noticed in a species of Gryllus; and, finally, M. Treviranus, a sort of membranous drum, situated on the forehead of certain nocturnal Lepidoptera. All these parts are too inconspicuous to have any claim to the important function under consideration; besides, they have been observed, (nay, they may be safely affirmed to exist) only in a few species, whereas the sense that has been ascribed to them must be universal throughout the class.

Taste is one of the senses whose organs have not been fully determined. Judging from analogy, it should reside in that part of the mouth corresponding to the tongue, and as that exists in tolerable distinctness in many tribes, it has usually been assigned thereto. The membrane which lines the interior of the oral cavity, doubtlessly shares in this function; and in the suctorial races, which probably possess it in a very inferior degree, it must have its seat at the

tip of the proboscis, which is commonly provided with glandular points.

The sense of *smell*, or at least some power which communicates analogous intimations to the sensorium, is in a high state of perfection; for the distance from which insects are attracted by the fetor of some choice pabulum, or the scent of some favourite flower, (such as the catkins of the willow in early spring,) is truly astonishing. Yet nothing is more uncertain than the organs by which this service is so admirably performed; and there is scarcely any part of the body to which the olefactory perceptions have not been assigned by different physiologists. Lyonnet, Bonsdorf, and Marcel de Serres, considered the palpi as the organs of smell; Camparetti, various appendages of the head; Rosenthal and Robineau Desvoidy, a small vesicular membrane, between the antennæ of the Muscidæ; and Kirby and Spence, the *rhinarium* or nostril-piece. The last named authors detected a pair of spongy bodies under the tegument of the part so named in *Necrophorus Vespillo* and *Dytiscus marginalis*, and they suppose similar parts to exist in other insects. But M. Treviranus, and other anatomists, have been unable to discover them, and there can be no doubt that the Fathers of British Entomology have, in this rare instance, fallen into error, or at least assigned too much importance to a variable, evanescent, and non-essential part of structure.

From the consideration that this sense, in the vertebrata, is closely connected with the act of respira-

tion, other authors are inclined to place it in the tracheæ, either in their external margins or interior ramifications. Cuvier is of opinion that they are very well calculated to perform the office, the internal membrane being soft and moist, and fitted to receive odours from the air.* It must be admitted, that this hypothesis receives no support from the experiments of Huber, who found that bees were insensible to the smell of oil of turpentine, which they particularly dislike, unless it was applied to the base of the trunk near the cavity of the mouth. But the experiments of Lehmann afforded opposite results, and Huber's observations must therefore be considered inconclusive. Upon the whole, we have not sufficient grounds to come to any decision on the subject, although the probability is in favour of the tracheæ being organs of smell as well as of respiration.

The organs of sight are usually large and conspicuous, forming, as it were, the lateral portions of the cranium, sometimes meeting at their inner edges, and thus occupying greater part of the head. Owing to their structure, they have received the name of *compound eyes,* and they are often aided in their functions by another sort, in the form of small chrystalline points placed on the forehead, which are called *simple eyes, ocelli, or stemmata.* When present, the latter are generally three in number, placed in the form of a triangle on the crown; sometimes there are

* There really does exist, notwithstanding Kirby and Spence's assertion to the contrary, an internal membrane, although it is very thin and closely adherent to the spiral thread.

only two, and in a few instances only a single ocellus has been detected. Their internal structure renders it obvious that they are organs of vision. Müller is of opinion that their refraction must be very great, the convex cornea, the anterior convex surface of the lens, the posterior convex surface of the lens, and, finally, the convex surface of the glassy body itself, each having the power of refracting a ray of light. It is improbable that they are of any use in distant vision, but they are fitted to give a distinct view of objects close at hand, and are doubtless designed to facilitate the insect's operations in the narrow passages tubular flowers, &c., where they are so often em ployed.

When we look at a composite eye, it is found to present a reticulated appearance, which is occasioned by its being composed of an aggregation of minute hexagonal pieces. Each of these pieces is a distinct lens, and constitutes in itself a complete organ of vision. Their amount has been calculated in a variety of species, and in most cases found to be astonishingly great: 7000 have been counted in the eye of a common fly; 12,544 in a dragon fly; 11,300 in the goat-moth; 17,355 in a butterfly; 25,088 in a species of mordella; 1300 in the convolvulus sphinx; 50 in an ant,* and about the same number in *Xenos*. The eye consists of various layers; first of a hard, transparent, facetted membrane, which may be regarded as

* A few species of foreign ants (Gen. *Ponera*, &c.) are among the very few insects with which we are acquainted which seem to be entirely destitute of eyes.

a cornea; beneath this there is a layer of opaque matter, varying in colour, but most commonly black, deep violet, red, or green, which produces the brilliant spots and bands on the eyes of Tabanidæ and other flies; lying below this a dark-coloured varnish, which may be considered as a choroid: numerous air vessels are supplied to the last mentioned part, and there is a space beneath for receiving some of the ramifications of the optic nerve. According to Müller, who has been most successful in explaining the structure of these organs, each individual facet can survey but a small space of the entire field of vision, so that each contributes to the perception of all the objects within the field; but each separate one does not at the same time see all such objects, whence the insect must receive as many forms of objects in its eye, as there are individual facets to the eye. This consequence of a common and yet subsidiary vision of these facets, springs partly from the immobility of the eyes, and partly from the circumstance that only those rays of light which fall in a right line upon a facet of the eye, which itself forms the segment of a circle, can reach the optic nerve of this facet, whereas all others are withheld by the pigment which partly separates the individual glass lenses from each other, and partly surrounds the margin of the chrystalline lens, beneath the cornea. From this it follows, that the nearer the object is the more obliquely do all, but the perpendicular rays of light, fall upon the facet; and, therefore, contribute so much the less to the production of the image; the object consequently is most

clearly seen closely, and more indistinctly at a distance. Now, if each facet of the eye can survey but one small portion of the field of vision, yet will the entire eye be able to survey a field the larger in proportion to the size of the segment of the circle it forms, and to the convexity of its arch. In accordance with this view, we find the eyes of predacious insects, and such as require powerful vision, prominent and globular; and the reverse is witnessed in parasitical species, and others to which the perfection of this sense is less essential. Each separate cone or lens, must be understood as conveying the impression it has received from a ray of light to the nervous filament with which it is supplied; and as the latter are all united in the great optic nerve, a common and distinct image is ultimately produced.

Compound eyes are almost invariably two in number; frequently, however, they are partially or even completely divided by the antennæ being inserted in the middle, and in such cases four appear to be present. Whirlwig beetles (*Gyrinus*), and certain Ephemeræ may be said to have an upper and under pair. Their degree of projection from the head generally depends merely on their greater or less convexity, but in not a few instances they are placed on pretty long footstalks. The size of the eyes is often a mark of sexual distinction, as we shall have occasion to mention more particularly in the general history of the order Diptera.

Reproductive or Generative System.—Among insects the sexes are always distinct, and the organs

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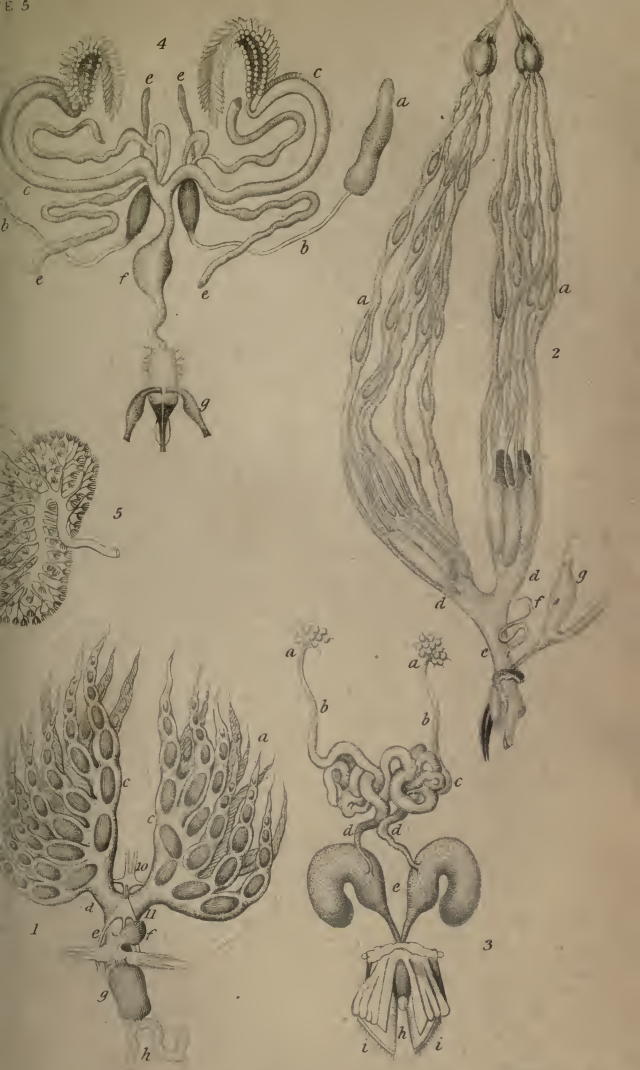

Generative organs.

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estined for the propagation of the species, may be id to have a general correspondence with those of ne higher animals. They occupy the hinder part of ne abdomen, and the external organs pass out by a istinct outlet, lying a little below the orifice of the limentary canal. In the female, the following rgans exist; the *ovaries, oviduct, and vagina;* esides various peculiar parts, as well as certain exerior appendages designed to convey the eggs in afety to their nidus, or to act as instruments of deence, termed ovipositor and sting.

The ovaries are membranous tubes or bags in hich the eggs are generated, and where they reain till they acquire a considerable size. They re divided into two pretty equal portions, one lying n each side of the abdomen. Their shape is very ariable, but most of them may be referred to the ree following types of form. 1. Simple bags, ontaining the germs of the eggs. 2. Short ovries, thickly placed over the surface of a large ag-shaped common ovarium. 3. Long tubular varies, containing many eggs, resembling a necklace, ither entirely free, or united by a loose cellular ssue.

The oviduct is the canal which emanates from ach half of the ovarium, and which both unite in the ntodian line of the body, and form a common evaating or ejaculatory duct. The length and capacity f these canals vary greatly. Sometimes they are upplied with glandular appendages, for the purpose f elaborating a glutinous matter, which forms a

coating to the eggs before they are extruded. This varnish, however, is more commonly imparted to them in the wider part of the duct, formed by the union of the tubes from the two branches of the ovaries. This common duct is sometimes called the egg-canal. It is of greater diameter than the oviduct and frequently distended in the middle where the egg occasionally remains stationary for a time before being expelled. Of the various appendages of this portion of the egg-conduit, the most important are the sperm-reservoir, (*Spermatheca*) gluten secretors, and the poison vessels of the aculeate Hymenoptera. The former is a purse-shaped appendage or distention of the duct, destined for the reception of the male influence during copulation and, according to Herold, the eggs are impregnated in passing it, for it is situate on the upper side, and whenever it opens the sperm flows into the duct. The gluten secretors are commonly more slender, and of a vascular structure, performing the office of a gland. The liquid they secrete is white, and it envelopes the eggs in their passage. Their situation is very close to the sperm reservoir. The poison vessel of the Hymenoptera is an ovate bladder with a narrow duct appended to it, which discharges the contents into the sting.

The vagina is simply the terminating portion of the evacuating duct; a short straight tube, generally a little narrower than the common branch of the oviduct. When an ovipositor exists, the vaginal tube opens directly into it, forming a continuous

canal a considerable way beyond the extremity of the body.

In the male the principal internal generative organs are the *testes, vasa deferentia, vesicula seminalis,* and *ductus ejaculatorius:* the external are the *penis,* and the *prehensory organs* connected with it.

Like the majority of the secreting vessels in insects, the testes are commonly slender and convoluted, and they occupy nearly the same portion of the abdomen as the ovaries in the opposite sex. Sometimes there exists only one globular body, as is found to be the case among the diurnal and crepuscular Lepidoptera; frequently a pair, and not rarely four separate ones varying in size. In their forms and disposition they vary almost without end in different groups. The ducts by which they are united to the common ejaculatory duct constitute the *efferential vessels* (vasa deferentia), which are usually slender throughout the greater part of the course till they become dilated into an oval or kidney-shaped bladder, which is the *vesicula seminalis.* The size of the latter generally bears some proportion to that of the testes, and in not a few cases it appears to be wanting. This sperm bladder terminates in a tube, joined to the corresponding one from the opposite side, forming by their union the ejaculatory duct, which is analogous in shape and situation to the egg canal of the female. Sometimes it is short and broad, at other times moderately long. The other male organs mentioned above may be considered as external. The prehensile appendages are well exem-

plified by the Dragon-flies, which have them so prominent that they are sometimes supposed to be stings. By means of them the male is enabled to retain the female, and even fly about with her in such a position as to have given rise to the erroneous notion that the genitalia in these insects are placed in the anterior part of the body. In this respect they form no exception to the general rule.

Pl. V. fig. 1, represents the generative organs of the female of *Athalia centifoliæ*, from Mr. Newport's excellent essay on that insect: *a*, *a*, the ovarial tubes; *c*, *c*, the uterine cavities; *d*, the separate oviducts; *e*, the common or ejaculatory oviduct; *f*, the spermatheca; *g*, the poison gland, *h*, its vessel; 10 and 11, the terminal ganglia lying upon the ejaculatory oviduct before the sperm-bladder.

Fig. 2, generative organs of the female of *Ranatra linearis*, the same letters as in the preceding figure indicating corresponding parts; *g*, supposed swimming bladder, with a part of the intestine.

Fig. 3, male generative organs of *Athalia centifoliæ*; *a*, *a*, smaller testes, *b*, *b*, the ducts, *c*, larger testes, *d*, *d*, vasa deferentia, *e*, vesiculæ seminales, *h*, ejaculatory duct, *i*, exterior valves.

Fig. 4, generative apparatus of the male of *Hydrous piceus*; *a*, *a*, testes, *b*, *b*, vasa deferentia, *c*, *c*, principal seminal vessels, *e*, *e*, *e*, *e*, various accessory vessels, *f*, ejaculatory duct, dilated in the middle, *g*, copulative armature of the vagina.

Fig. 5, testicle of *Silpha obscura* greatly magnified.

Muscular System.—When we reflect on the varied movements of insects, their different modes of progression, walking, leaping, swimming, flying, &c. and the great degree of strength which they exhibit,

It is evident that their apparatus of muscles, on which all these acts depend, must be at once ample and powerful. Although Lyonnet's enumeration of the muscles of the cossus has been often cited, we are acquainted with no other instance which so well exemplifies their wonderful multiplicity. In that caterpillar he discovered no fewer than 4061, of which 228 belong to the head, 1647 to the body, and 2186 to the intestines, a number exceeding by 3532, the amount of those which are to be found in the human frame!

In some respects the muscles of insects have a strong similarity to those of the vertebrata, but in others a notable discrepancy is observable. For the most part they consist of two portions, viz. the tendon and the muscle. The muscle properly so called, is formed of a multitude of straight fibres, and enveloped, according to Lyonnet, in a membrane composed of many parallel bands, consisting of bundles of fibres enclosed in separate membranes. At one extremity they are attached to the inside of the external crust, and the various processes connected therewith, at the other to the organ on which they are designed to operate, their attachment being either immediate or by means of a tendon. When the muscles are not provided with tendons, the shape is determined by that of the parts to which they are attached, and they are commonly cylindrical or prismatic, retaining their sides parallel throughout their whole course. Those which are furnished with tendons are more variable in form, and have been divided into several classes

which we cannot here afford room to enumerate and characterise. As the parts in question exercise precisely the same functions as among the higher animals, the same terms are applied to them, and they are spoken of as flexor, extensor, abductor, adductor, rotatory muscles, &c. appellations which scarcely require any definition. We shall mention a few of the principal ones in the different parts of the body.

Muscles of the Head.—The head having freer motion than any other part, except the pedunculated abdomen of aculeate species, is furnished with a corresponding provision of muscles. Those which move the whole head, when that part is sunk in the prothorax, for the most part consist of four pairs, besides three other subsidiary pairs which contribute more or less directly to aid their movements. When the head is pedunculated, the muscles are very small and rudimentary. Of those which produce the motions of the oral organs, a pair only are appropriated to the mandibles; the maxillæ, being composed of a greater number of pieces, and bearing the palpi, have each nine attached to them; the palpi have each a pair, and every separate joint is similarly provided. A single muscle, or at most two, suffice for the limited motions of the labrum, but its counterpart, the labium, whose action is more frequent and extensive, is furnished with four, besides those appropriated to the palpi. The motive apparatus of the antennæ consists of three general muscles for each, and two others, an extensor and flexor, for every individual joint. Besides these, several muscles are to be found in the vicinity of the pharynx, whose office

t is to retain that portion of the central canal in its place. The brief enumeration now given refers to masticating insects alone; it will readily be understood that the muscles are greatly modified in sucking insects, since in these the parts of the mouth have undergone an important change.

Muscles of the Thorax.—The muscular system of the thorax has for its office to unite the component segments of that portion of the body, and to furnish a motive apparatus for the organs of locomotion, the wings and legs. They differ somewhat according as the prothorax is free or connate with the succeeding segments. In the former case, (as among the Coleoptera, for example,) the principal mass of the muscles is concentrated in the prothorax, and they are almost wholly employed in effecting its free movements, there being no wings to be supplied. In general, four pairs can be detected, which have their posterior attachment in the mesothorax, and an orbicular one accompanies each spiracle. The mesothorax, in the kind of insects of which we now speak, is provided with three pairs of muscles, all of which have greater or less influence on the motions of the anterior wings. A like number, and acting mediately in a similar manner, is found in the metathorax; the largest, which occupies the upper part, assisting to depress the posterior wings, the second, placed at its side, to draw them backwards, and the third to elevate them. Besides these principal muscles, numerous others of smaller size occur in the metathorax, consolidating the various pieces of which it is composed, and also acting for other purposes.

Muscles analogous to those just noticed exist in insects whose prothorax is connate, that is, intimately united to the succeeding segment; but, in these the mesothorax being most highly developed, it is there that they acquire their greatest dimensions, and one pair is generally enlarged at the expense of another. Thus, the dorsal pair is most voluminous in the Hymenoptera and Lepidoptera, while it is the lateral pair in the Diptera.

Many of the muscles already noticed contribute, in a greater or less degree, to promote the act of flight, by contracting or dilating the walls of the thoracic cavity, but there are a few to which the office of moving the wings is exclusively assigned. These originate from the lateral parts of the sternum, and are attached by pointed tendons to the principal nervures of the wing. Their development is always in proportion to that of the wing which they are destined to move. If the anterior wings be largest, as stated by Burmeister, the dorsal muscle of the anterior wing is likewise the largest; if the posterior wings are wanting, their extensor is also wanting, and if both are of equal size, their extensors also are of equal size; but, if the posterior wings are the largest, this is likewise the case with their extensors, as may be seen in the Coleoptera, while the extensor of the elytra in that order is very small. A small extensor, flexor muscles, and a series of smaller ones, which, when in action, cause the relaxation of the extensors, are the other motive instruments of the wings.

From the free movements of the legs, and the number of separate pieces entering into their composition, it may be presupposed that they have obtained a large supply of muscular power. The coxæ receive the greatest number of muscles, especially if of a globose form, and performing a rotatory movement upon their axis. Four extensors and a flexor, according to M. Strauss, is the complement of the anterior and posterior coxæ of the common cockchafer, and three flexors and two extensors of the middle coxæ. The muscles of the trochanter are inserted in the coxæ, and, like those of the latter, vary in number. In the insect just named there are three extensors and a flexor for those of the anterior legs, and only a single flexor and extensor for each of the others. The thigh is moved by two muscles, and the tibia by a like number, the tarsus by two general ones, and a pair appropriated to each separate articulation. The last joint has two peculiar ones which act upon the claws.

The muscular apparatus of the abdomen is much more simple than that of any of the other primary divisions of the body. It consists chiefly of a series which serve to unite this part with the thorax, and of another designed to maintain the connection of the different segments with each other. They are in general broad flat ribbons, rather thin and deprived of tendons. The organs of generation, owing to the complicated movements they perform, necessarily employ a great number of muscles, which assume as great a variety of forms as the organs themselves, and of which, therefore, it would be unsatisfactory to at-

tempt any general description, especially as they are very imperfectly known.

We have now entered, as far as our limited space will admit, into the history of the external and internal organisation of insects, a department of natural history fraught with interesting subjects of research, and exhibiting, in so conspicuous a manner that it can scarcely fail to strike the most insensible, the GOODNESS and POWER of that adorable INTELLIGENCE which has provided for the wellbeing of the lowliest of his creatures, by a mechanism and a vital system even more complicated than among the higher animals, and equally deserving of our admiration. What we have further to add illustrative of their manners, instincts, geographical distribution, &c. will be given in the systematic exposition of the different orders, a branch of the subject which occupies the remainder of the volume.

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SYSTEMATIC ARRANGEMENT OF INSECTS.

The necessity for an accurate methodical classification by which living objects can be recognised and their relations to each other in some measure indicated, is even more strongly felt in regard to insects than any other department of the animal kingdom. This is occasioned by the great amount of their numbers, which much exceeds that of any other of the zoological classes. Most authors agree in affirming that not fewer than between 80,000 and 100,000 species are preserved in collections, and it is computed that the species existing in nature is not greatly short of 400,000. But the very circumstance which makes a well digested arrangement so desirable, likewise renders it of no easy attainment, owing to the difficulty of acquiring the requisite knowledge of such a multitude of objects. Their structural details are so endlessly diversified, their affinities and analogical relations so complex, and their modes of living, in many cases, of such difficult determination, that it is scarcely to be expected that a system will soon be constructed in which each shall find its appropriate position, a position at once forming a faithful index to all its most characteristic and essential properties. How far some

of the plans now zealously advocated by a few naturalists in this country promise to answer this end, forms no part of our present purpose to enquire. In common with all others hitherto proposed, they recognise certain primary divisions of the class, many of them corresponding, or nearly so, to those established by Linnæus; these divisions, therefore, as forming the most generally approved basis of arrangement, and of fundamental importance in every point of view, we design to explain at some length, and illustrate by a variety of examples. They are termed *Orders*, and are the first subdivision of the class. The following is a tabular view of them, with concise distinctive characters.

Insects

- with wings. Mouth
  - organised for gnawing, wings
    - four,
      - of unequal consistency, the under pair folded
        - transversely, — COLEOPTERA.
        - longitudinally, — ORTHOPTERA.
      - of equal consistency,
        - reticulated, — NEUROPTERA.
        - veined,
          - naked, — HYMENOPTERA.
          - hairy, — TRICHOPTERA.
    - two, ... — STREPSIPTERA.
  - organised for sucking, wings
    - four,
      - not clothed with scales, — HEMIPTERA.
      - clothed with scales, . — LEPIDOPTERA.
    - two, ... — DIPTERA.
- without wings.
  - undergoing metamorphosis, . . . — APHANIPTERA.
  - no metamorphosis,
    - mandibulated, — THYSANOURA.
    - suctorial, . . — PARASITA.

Each order is generally subdivided into comprehensive *Sections* according to the number of joints in the tarsi, structure of the antennæ, conformation of

the wings, &c. The next step in the process of subdivision is commonly to *families*, which consist of a group of genera agreeing in certain general characters. Subordinate to this is the group termed a *genus*, comprehending species conformable to each other in all essential parts and organs. The *species* is the lowest gradation of all, unless a *variety* be taken into account; the former has been well defined as a natural object, whose differences, from those most nearly related to it, had their origin when it came from the hands of the CREATOR, while those that characterise the latter have been produced since that event. Other groups, besides these, are occasionally adopted by systematists, but as scarcely two ever use them in precisely the same acceptation, their value and import must be learned from the definition each particular author assigns to them.

ORDER I.—COLEOPTERA.

We must refer to the volume on Coleoptera (Beetles), for a full account of the peculiarities as well as the history and representation of many of the most remarkable species of this important order; and we shall here content ourselves with giving such a brief notice of its more prominent features, with a few supplementary details, as will lead to a right understanding of the method of division here followed, and prepare for a more lengthened exposition of the following orders:—

The upper wings are hard and horny throughout their whole extent, forming a protecting cover to the under pair, and are therefore named *elytra*. From this circumstance also the name of the order is derived, being compounded of κολεος, a sheath, and πτερα, wings. Where the elytra, or wing-cases, meet, they form a straight sutural line along the back. The under wings, which are the true organs of flight, are membranous and transparent; when at rest they are folded transversely. The mouth is constructed for mastication, and all the parts are very highly developed. Stemmatic eyes have not been observed in the perfect insect, except in the genera Onthophagus, Omalium, and Paussus; but they are the only kinds with which the larvæ are furnished. The prothorax is very freely articulated to the succeeding segment, and the pronotum is so large as to form a considerable part of the dorsal surface. On each side of the pronotum, in the carabideous and aquatic beetles, there is a distinct corneous scale from which the muscles of the coxæ originate, called the smaller or anterior shoulder-blade (*omium*) by Burmeister. The horns and other prominences frequently rising from the prothoracic case are mere processes or integral portions of its crust, except in one instance, the Harlequin beetle (*Acrocinus longimanus*), which has a large moveable spine on each side. The only portion of the mesothorax appearing on the surface, is the small triangle named the scutellum; its whole volume, indeed, is comparatively contracted, owing, no doubt, to the elytra which it supports not being

designed to take an active share in flight. That function being entirely devolved on the membranous wings, which receive their impulse from the muscles of the metathorax, that segment is proportionably augmented, its dimensions frequently equalling those of the prothorax.

These insects undergo a complete metamorphosis. In a few exceptional cases, notwithstanding, the larva bears a close resemblance to the imago, as, for example, in Drilus, the female glow-worm, and almost the whole family of the Staphylinidæ. In such an extensive order, the larvæ are, of course, of very varied aspect; commonly they are soft and pale, the head, and a few of the anterior segments alone being corneous. The absence of the brilliant colours which often distinguish the perfect insect, is to be attributed to their usually frequenting places where they are concealed from the light; some living beneath the ground, others in the stems of trees and herbaceous plants, putrescent fungi, decaying vegetable and animal matter, &c. In such situations long antennæ would be an encumbrance to them, and these appendages accordingly are in all cases short and inconspicuous. Most of them possess six thoracic legs, without any auxiliary organs of motion, but not a few are entirely apodal, the only substitutes for legs being small warts or prominences. Such as are aquatic, effect their motions in the water merely by the action of the legs, aided probably in *Gyrinus* and *Hydrophilus caraboides*, by the plumose or fin-like branchiæ placed along the sides of the body. The

number of simple eyes, the only kind with which these larvæ are provided, varies from one to six; the former is exemplified by Telephorus, the latter by Carabus. In the larvæ of Cicindelæ the two posterior ones have a red pupil surrounded by a pale iris. The larvæ of many different kinds—commonly termed *grubs* by husbandmen—are productive of great injury to cultivated plants, both when growing, and after they have been harvested.

Of all the orders perhaps this is the one that has been most studied, a preference which it owes to the great beauty of many of its foreign species, the endless diversity and singularity of their forms, the distinctness of their external parts, and the ease with which they can be preserved in unimpaired beauty for an indefinite length of time, as well as other considerations, calculated to recommend them to notice. It is partly from the zeal with which they have been sought after, that their number has always appeared so much greater than that of the other orders, which, now that they have attracted more attention, are found to make a nearer approach to them in this respect than was formerly imagined; still, however, the preserved examples are considerably most numerous, as is likewise, there can be no doubt, their absolute amount in nature. The collection of the Count De Jean has been augmented, in the short period that has elapsed since we last mentioned the amount of its contents, to nearly 23,000 species, and it is conjectured that about 6000 or 7000 others exist in the Parisian cabinets. The collection of beetles in

the Museum of the University of Berlin, the richest that exists, consists of no fewer than 28,000 species; and when we consider how many others must be contained in the cabinets of England, Holland, Germany, and other places, not to be found in these, we are justified in affirming that upwards of 40,000 distinct species of Coleoptera actually exist in collections. It is more difficult to form a satisfactory estimate of their total amount in nature. The following is the most recent attempt of this kind we have seen; and, in connection with the adjoining table, will shew, at one view, the supposed relative extent of the different orders, both as actually known, and as they exist in all the countries of the globe :—

	Supposed to exist in Collections.	Supposed to exist in Nature.
Coleoptera	40,000	120,000
Diptera,	10,000	100,000
Hymenoptera,	12,000	72,000
Hemiptera,	5000	25,000
Lepidoptera,	10,000	20,000
Parasita,	500	10,000
Neuroptera,	1,500	9000
Orthoptera,	1000	6000
	80,000	362,000

The following table indicates, but in a manner which can only be regarded as an approximation to the reality, the ratio in which the Coleoptera increase in receding from the poles and approaching the equator, in obedience to that most general of all laws regulating the distribution of animals on the earth's

surface, viz. the augmentation of their numbers with an increase of temperature:—*

Countries.	Latitude.	Authorities.	No. of Species.
Melville Island, (Winter-Harbour.)	75° N.	Kirby, ...	0
Greenland, . . .	60°-70° N.	O. Fabricius, .	11
Lapland, ...	64°-71° N.	Zetterstedt, . .	813
Sweden, ...	56°-69° N.	Gyllenhal, Paykull,	2083
England, ...	50°-61° N.	Stephens, . . .	2263
France, ...	41°-51° N.	De Jean and others,	4200
Brazil from Rio-Janeiro to Bahia,	13°-23° S.	De Jean, Klug, Perty, &c.	7500

In like manner may be exhibited, in a general way, the relative amount of the genera into which a given number of the species of certain countries, or entomological regions have been grouped:

Country.	Species.	Genera.	Average Number of species in each genus.
Siberia, . . .	465	169	2,7
Europe, . . .	5,677	715	7,9
North America,	2,403	541	4,4
South America,	8,112	1209	6,7
Africa, ...	2,942	674	4,3
New Holland, .	320	162	2,0

Order II.—Orthoptera.

In immediate succession to the order of which we

* In making this attempt, it was of course necessary that as nearly as possible the same extent of the different countries should be compared with each other.

have just been treating, most authors agree in placing the important one above named. This position, in the series of ordinal groups, it has obtained in consequence of presenting many properties in common with the coleoptera; some of the older entomologists, indeed, regarded them as so closely allied, as not to admit of separation. But this opinion could only result from an imperfect acquaintance with their respective characters; for in the present instance, the peculiarities are sufficiently distinctive and important, fully to entitle this order to the rank which it now holds.

The name having been applied in conformity with what has been called the *Alary system* in entomology, has reference to the nature and peculiarities of the organs of flight. These are found to be folded longitudinally when at rest, and *ορθος straight*, *πτερα wings*, affords a term indicating this disposition. As in the preceding order, the wings are four in number. The anterior pair are of a pretty stiff substance, resembling parchment, serving both for the purpose of protecting the inferior wings, and also assisting in flight. In the former respect, they perform the same service as elytra, but in the latter share in a function to which elytra cannot be said to be directly subservient. Instead, therefore, of having that name applied to them, as is often done, it is better that they should have a distinctive appellation of their own; and of the various terms that have been used, *tegmina* seems the most appropriate. In far the greater number of instances they do not form a straight line along the back, where

the inner edges approximate when closed, but the one usually overlaps the other. Although, for the most part semi-membranous, they vary considerably in consistency in different tribes. In certain species of *Mantis*, for example, they nearly assume the appearance of transparent reticulated wings, while among the convex-backed *Blattæ* they approach to the rigidity of elytra. They are generally reticulated by a series of strong nervures, radiating from the base to the summit, and crossed by a multitude of smaller ones, resembling fine lace. Sometimes, however, these nervures are visible only at the apex of the tegmina, but their existence is always obvious on the under side. Among the *Grylli*, the males of which are provided with a musical apparatus, situated at the base of the abdomen, some of the nervures are much more prominent than others, and instead of being longitudinal, are curved in a variety of ways; it is by rubbing these against the apparatus mentioned, that these insects produce the peculiar noise for which they are remarkable.

The under wings being adapted solely for flight, are of a much more delicate texture than the superior pair. They are traversed by a series of pretty strong parallel nervures, diverging from the base, and are folded up and expanded nearly in the same manner as a fan. From this cause they cannot be packed in so small a compass as in beetles, the wings of which are folded transversely upon themselves; accordingly, they are not always quite covered by the tegmina when at rest, and in some instances they

project beyond the extremity of the body, producing the appearance of a tail, as may be seen in *Gryllus*, *Gryllotalpa*, &c.

This order is one of those in which the mouth is said to be perfect—that is, having all the constituent or essential parts that exist in the most typical tribes fully developed. Not only is this the case, but they are likewise of a hard or osseous consistency, apparently fitted for all the functions they perform among the coleoptera, and shewing no tendency to become obsolete, as is the case with those orders at the opposite extremity of the series. The description, therefore, that has been already given of the oral organs of the coleoptera, will serve to convey a general notion of their appearance in this order, and supersede the necessity of adding much to what has been already said.

The upper lip, (Plate VI. fig. 2, *d*, and fig. 3,) in general, is very conspicuous, and, as in all other orders, very variable in its shape. It is somewhat peculiar in orthopterous insects, by being frequently unequal on the surface, occasionally ciliated, or provided with tufts of pretty long hair, and armed with teeth on its anterior edge.

As might have been expected in insects, many of which have long attracted observation by their extensive depredations on vegetable substances, the *mandibles* are large, powerful, and efficient. They present the ordinary forms, being more or less triangular, arched on the outer side, and armed with teeth on the inner edge. If Marcel de Serres' ob-

servations be correct, which they are admitted to be in general, the mandibular teeth of the Orthoptera offer this peculiarity, that they have a coriaceous and transverse plate, (*lame*) at their base, which seems to separate them from the body of the mandible; whereas in other cases, the teeth are well known to be only projecting pieces of the substance of these organs. The same observer, adopting an idea first started by Knoch, regards these dentations as bearing so close a relation to the mode of nourishment, that by observing their structure, distinct intimation may be obtained of the kind of food used, and consequently in some degree of the habits of the respective species. He divides them according to their analogy to the dental system of mammiferous animals, into *incisive, canine,* and *molar.* The former are large, somewhat resembling a curved wedge, their external surface convex, and the opposite one concave; a form which renders them eminently fitted for cutting: the teeth at the extremity of the mandibles of Locusta exemplify this modification. The canine teeth are conic, often very sharp, and lengthened, and are of course characteristic of such genera as Empusa and Mantis, which are purely carnivorous. The molars are large, short, and fitted for bruising alimentary substances. Never more than one exists in each mandible situated at the base opposite to each other. The species provided with the first and last mentioned description of teeth are herbivorous; and when they exist simultaneously, which happens occasionally in such species as are

omnivorous, they are usually of small dimensions. (Plate VI. fig. 4, mandibles of the house cricket with incisive teeth. Fig. 4^{x}, one of the mandibles of Acrydium, with a large molar plate near the internal base, *b*.)

The organs which next require to be noticed, are the *maxillæ* or under jaws. As they are employed for a similar purpose as the mandibles, they have a corresponding development; they are in fact often of large size, and in their general forms not unlike those of the carnivorous coleoptera. They are always glabrous in this order, or clothed with such short hairs as to be almost imperceptible. The maxillary palpi, (Plate VI. fig. 5, *c*) are always five-jointed in this order, whereas the normal number among the Coleoptera appears to be four. The portion called the blade of the maxilla, is that which forms the apical extremity; it is usually incurved and bifid at the tip, (Plate VI. fig. 5, *a*.) It bears externally a distinct lobe, corresponding to what are frequently described as internal maxillary palpi. The name *galea* or helmet is now applied to this piece, (Plate VI. fig. 5, *b*.) It is frequently palpiform, consisting of two joints, and in some instances, (as in *Acrydium*) apparently of three; but in all cases it is dilated at the extremity somewhat in the form of a helmet, being vaulted, and covering the apex of the maxillæ to which it is usually closely applied. This is an important piece owing to the part it takes in nutrition, and the permanence of its forms in different species.

The *labium* or under lip is rather of a more com-

plex structure, and the nomenclature of its separate parts somewhat involved. On examining the figure of the lower lip of the domestic cricket, (Pl. VI. fig. 6) it will be observed that it is divided into three distinct parts by means of well defined lines. The basal portion, (*a*) by which the whole labial apparatus is attached to the head, Kirby regards as the *mentum*. The second division (*d*) he considers as more directly answering to what is strictly called the labium in other insects; and the terminal portion (*e*) is merely an additional articulation to it, divided into two, three, or more lobes. "At first you would imagine the terminal part of this organ to be the analogue of the tongue, or ligula F; as it is indeed generally regarded by modern Entomologists. It seems like the tongue of the *Carabi* L, *Dytisci*, &c. to be a distinct piece, which has below it both labium and mentum: but when you look within the mouth, you will find a linguiform organ, which evidently acts the part of a tongue, and therefore ought to have the name; and the piece just alluded to must either be regarded as the termination of the lip, or as an external accompaniment of the tongue, analogous, it may be, to the *paraglossæ* in bees." *

The labial palpi are variously described by authors as consisting of three or four articulations. The number of joints is certainly alike in all the species, and the discrepancy alluded to, has probably arisen from some observers having included the minute

* Introd. to Entom. III. 424.

radical joint in their enumeration, while others have overlooked it, or regarded it merely as a point of support to the palpus. Although frequently almost lost in the substance of the labium, this joint appears however to be always present, and although apparently three-jointed, the palpi must therefore be regarded as really composed of four articulations, (Plate VI. fig. 6, *c*, *c*.)

The tongue, (*lingua*,) generally a very obscure member of the oral appendages, is very distinct in some of the insects of this order. It is short, retracted within the mouth, rather of a soft substance, and in some instances, as in Blatta and Locusta, it bears a pretty close resemblance to the tongue of a vertebrate animal.

The modifications of the antennæ will be specified afterwards as aiding in the discrimination of the different groups. In general they are long, setaceous, and extremely flexible, consisting of fourteen, sixteen, or twenty-five joints among different species of Locustæ; of above thirty among the Mantes; while in the Blattæ or Cockroaches, the articulations sometimes amount to 150, and vary even in individuals of the same species.

Besides the ordinary compound eyes, which in general are large and prominent, the insects of this order are mostly provided with three simple eyes situated in the crown of the head. In the genus Blatta, the domestic cricket, and some other instances, these auxiliary organs are wanting, but there is a subdiaphanous space over the base of the antennæ

in Blatta which may be regarded as representing them.

The *clypeus* or shield is always distinct among the Orthoptera, (Plate VI. fig. 2, *c.*) In several families of this order, "the suture, uniting the shield with the upper part of the skull, is membranaceous; hence the lip and shield move simultaneously with the mandibles in mastication. This is a departure from the general law of nature, and its occurrence is well worth remarking; as the motion of the shield might induce an observer to suppose it the lip, which would consequently become a new and supernumerary elementary part." *

Of the three segments composing the thorax, the prothorax is often very much developed, to such a degree indeed, that in a particular group of the old genus Gryllus it sometimes exceeds in size all the rest of the insect. The mesothorax is very inconspicuous in this order, for the reason, that the forewings do not take a very important share in flight, and the part which supports them therefore admits of diminution. It is scarcely observable, indeed, when the wings are closed, except in certain species of the Mantis tribe. The metathorax, which is seldom so much developed as the preceding sections in the generality of insects, here acquires considerable prominence, and in certain Phasmæ seems to have attained its maximum.

The metamorphosis of orthopterous insects, is what

* External Anat. of Ins. *Ent. Mag. vol. II.* 65.

is technically called *semi-complete*—that is to say, the changes in external form, which they undergo in their transition from one state to another, are only half so considerable as those which take place in some other instances—the Lepidoptera for example. In fact, it is difficult, in many instances, from inspecting an individual to say what stage of its progress it has reached. The final state, however, may usually be determined by the full development of the wings and tegmina; these members exist in the pupa only in a rudimentary condition. The pupa is never quiescent, but moves about and takes food. Not only do the larva and pupa resemble the perfect insect in external appearance, but it is likewise found on dissection that their internal organisation is similar. In the penultimate and antepenultimate states, the sexes are likewise distinct, and copulation sometimes takes place, but it is improbable that this premature union ever proves productive. The transformations in question, therefore, must be considered as merely a series of gradual approaches to perfection, none of the transitions being marked by any decided change of general form, the only consequences resulting from ecdysis, or casting of the external crust, being increase of size, slight development of certain parts, and an aptitude to continue the species.

This order is one of the least numerous in species. But its poverty in this respect is in some measure compensated for by the great amount of individuals of the same species, the swarms of locusts, grasshoppers, and cockroaches, which sometimes congre-

gate, probably exceeding every other assemblage of the insect tribes. In this country, not more than about fifty indigenous Orthoptera have hitherto been detected, and it is not likely that any considerable number have escaped the researches of modern collectors.

Although these insects must, of course, present a pretty general agreement in all essential parts of structure sufficient to justify their arrangement in the same division of their class, they are certainly very dissimilar in external aspect. The genera Forficula, Blatta, Locusta, and Phasma, bear almost as little outward resemblance to each other as the species of any two separate orders. It was this circumstance that led Dr. Leach to propose its division into three different orders, Dermaptera, including Forficula; Dictyoptera, including Blatta, and distinguished by the tegmina overlapping each other on the back; the other tribes to be referred to Orthoptera. The first of these has been since admitted by some authors to the rank of a separate order; among others, by Mr. Westwood, who names it *Euplexoptera*, because the term Dermaptera is said to have been completely misapplied by English Entomologists, having been originally proposed for the Cimicidæ. Notwithstanding the peculiarities in its structure which have led to this step, it is difficult, we think, to examine the earwig without being convinced that it is essentially an Orthopterous insect; and as that order must, in any case, be defined with considerable latitude, it can scarcely be regarded as an undue extension of it

to include the Forficulidæ. Dr. Burmeister, and some other of the modern continental naturalists, are decidedly opposed to any other step, regarding the distinctive characters as of no higher value than family ones. It is certain that if the principles on which the insects in question are separated from the Orthoptera, were in every case acted upon, the amount of orders would be at least double what it is at present. But whatever may be thought of the expediency of multiplying the great primary divisions of the class, the differences alluded to afford a ready means for dividing the order, as it now stands, into several well defined and very natural families or subordinate groups. Several of these are so strongly marked, that according to the ingenious observation of Professor Lichtenstein, the Jewish lawgiver, when he delivered his instructions to the Israelites, regarding the kind of food they were to use, distinguishes, as clean insects, the Fabrician genera, Gryllus, Locusta, Truxalis, and Acheta. "Yet these may ye eat of every flying-creeping thing that goeth upon all four, which have legs above their feet to leap withal upon the earth; even those of them may ye eat, the locust after his kind, and the bald locust after his kind, and the beetle after his kind, and the grasshopper after his kind."* Although Moses may have been led to do this *non sine adflatu divino*, still the discrimination, as Mr. Kirby remarks, presupposes a knowledge of their general characters in the people to whom the

* Leviticus, ch. xi. 21, 22.

precept was addressed, to whom it would otherwise have been *de ignotis*.

They naturally divide themselves into the following tribes, to each of which we shall successively advert, presenting a view of its general history, and illustrating it, in most instances, by figures of some of the most characteristic species:—Forficulidæ, (*earwigs,*) Blattidæ, (*cockroaches,*) Mantidæ, (*soothsayers* or *walking-leaves,*) Phasmidæ, (*spectres,*) Gryllidæ, (*grasshoppers,*) Locustidæ, (*locusts,*) Achetidæ, (*crickets.*) The first four of these, being all provided with feet formed for running, constitute Latreille's comprehensive family CURSORIA; the three last, which have thickened hinder legs adapted for leaping, compose his family SALTATORIA.

FAM. FORFICULIDÆ.

THE forms and appearance of the common earwig are so familiar to all, that we have thought it unnecessary to figure any of the species, especially since they are all very similar to each other; but as they present several peculiarities in their structure and habits, it is necessary to give some account of them, otherwise our exposition of this order would be incomplete. It has been already mentioned, that the disposition of the wings does not correspond to what is observed in other Orthoptera, since they are folded both longitudinally and transversely.* This arrange-

* Although the character afforded by the folding of the wings must be admitted to be a valuable one, its importance is obviously over-estimated when it is regarded as authorising

ment is rendered necessary by the extreme shortness of the tegmina, which would otherwise be quite inadequate to cover any considerable portion of the wing, and the latter would be exposed to continual injury. The tegmina are square, resembling the elytra of one of the Staphylinidæ, without veins, and the wings are somewhat ear-shaped, the nervures radiating from a point not far from the centre of the anterior border. The maxillary palpi are five jointed, but the terminal joint is very minute. The ligula is forked; the antennæ filiform, varying in the number of articulations from twelve to thirty, in different species, and even in different stages of the same individual.

Besides the common earwig, (*F. auricularia,*) there are at least four other species indigenous to Britain, and others are found in foreign countries; all our native kinds, however, are rare, except *F. minor*, (constituting the genus Labia of Leach,) which occurs not unfrequently, and is usually observed on the wing, which is not often the case with the common species. The latter are nocturnal insects, frequenting moist and shady places, and are particularly obnoxious to gardeners and florists for the injuries they commit to fruits and flowers. They are most partial to the

of itself the introduction of a new order. Some of the Coleoptera (such as *Bupestris*, *Molorchus*, &c.) deviate so far, in this respect, from their associates, as to have their wings simply folded longitudinally; but this is not connected with any other peculiarity which would warrant their separation from species to which, in other respects, they are intimately allied.

petals, and many of the most cherished ornaments of the flower border, particularly the stately dahlia, are frequently rendered unseemly by their attacks. The common earwig is widely distributed, and has been found as far north as Boothia.

The common names given to this insect in Britain are rather peculiar, and it is not easy to say what circumstances have suggested them. Throughout the south of Scotland it is known to the peasantry by the name of *coachbell*, for what reason I am unable to conjecture. Mr. Newman suggests that earwig, an unmeaning term, may be a corruption of *earwing*, as the wing is shaped very like the human ear, an explanation not unlikely to be the true one.

Several anomalies have already been alluded to in the structure of earwigs, and it remains to be added that a very remarkable one also occurs in their economy. Frisch, De Geer, and many other entomologists have observed the female watching over her eggs with great care, and even covering them with her body as if on purpose to hatch them, a fact which is well known to those who are in the habit of overturning stones in search of insects. This is a remarkable contrast to the practice of nearly all other insects, whose maternal duties entirely cease with the deposition of the eggs, which they abandon to every hostile influence. The young seem to appreciate and return their mother's affection, for they have been seen nestling under their parent like chickens under a hen. It must not be imagined, as some appear to have done, that the incubation alluded to is designed to hatch

the eggs, or could possibly promote their maturation if it were. The temperature of the body of a cold blooded animal is always in equilibrium with the surrounding element, and it could, therefore, impart no additional heat to objects subjected to the same influence in this respect as itself. The case is different when multitudes are congregated within a narrow space; heat is then generated, as is well known to be the case in bee hives.

Fam. Blattidæ.

The members of this family are very unlike the preceding, and they may be said to differ nearly as much from all the other tribes with which they are associated. Their bodies are in general broad, oblong, and depressed, the abdomen almost completely covered by the tegmina, which considerably overlap each other on the back, and wholly cover the under wings. The head is curved inwards beneath the prothorax; the antennæ very long, setaceous, and flexible, inserted in a notch in the inner side of the eye; the two lower joints of the maxillary palpi are somewhat globular, the terminal one (as is likewise the case with the corresponding joint of the labial palpi,) pretty thick and truncated. A conical and articulated appendage projects from each side of the abdomen behind. The legs are thickly armed with spines on the tibia, and all the tarsi consist of five joints.

Most of these insects are of a uniform brown colour, a hue well adapted to their habits and the nature of their haunts. A few, which usually frequent flowers, are

spotted and rather more gaily adorned, being, as Stoll affirms, no way contemptible in regard to colouring. They are nocturnal insects, and it was probably one of the species which, on that account, the ancients designated *lucifuga*. They are exceedingly voracious, scarcely any kind of edible substance coming amiss to them, and even attacking others which can scarcely be said to come under that designation; of the latter description are leather, silks, and woollen stuffs, which they gnaw with their well armed mandibles, and greatly injure. Their omnivorous and destructive propensities are well known in this country, from the prevalence of one of the species, (*B. orientalis,*) originally supposed to have been brought from the east, and now completely naturalised. It frequents cellars, bake-houses, kitchens, &c. is somewhat less than an inch in length, and of a dark reddish brown colour. The wings are shorter than the abdomen in the male, and merely rudimentary in the female, which, on this account, very much resembles the larva, when these organs are wanting in both sexes. It lays sixteen eggs, which are enclosed in a kind of bag of an oval shape, at first white but afterwards becoming brown. This is borne for a time at the extremity of the anus, and then deposited in some warm place, and secured to the spot by some adhesive gummy matter.

Besides the common species about a dozen others occur in Britain, but one-third of these have no claim to be considered indigenous, having been accidentally introduced along with foreign commodities. One of these exotic kinds, however, seems to have obtained

pretty secure footing in this country, particularly
n sea-port towns. This is *B. Americana*, or *kakerlac*,
pretty large species with very long antennæ, and a
ellowish thorax having a brown border and two spots
f the same colour on the disk. All the truly indi-
enous Blattæ are comparatively of small size and
eldom or never occur in such profusion as to occasion
uch injury or annoyance. Even the depredations
f the common *B. orientalis* are insignificant compared
vith those of foreign lands, where species of more
ormidable dimensions are sometimes so abundant and
bnoxious as to produce no trifling inconvenience to
he inhabitants.

"The cockroaches," says Drury in his work on
xotic insects, "are another race of pestiferous beings,
qually noisome and mischievous to natives or stran-
ers, but particularly to collectors. These nasty and
oracious insects fly out in the evenings, and commit
nonstrous depredations; they plunder and erode all
inds of victuals, dressed and undressed, and damage
ll sorts of clothing, especially those which are touched
vith powder, pomatum, and similar substances, every
hing made of leather, books, paper, and various other
rticles, which, if they do not destroy, at least they soil,
s they frequently deposit a drop of their excrement
vhere they settle, and, some way or other, by that
neans damage what they cannot devour. They fly into
he flame of candles, and sometimes into the dishes; are
ery fond of ink and of oil, into which they are apt to
all and perish. In this case they soon become most
ffensively putrid, so that a man might as well sit over

Blatta gigantea. 2 Blatta Petiveriana. 3 Harpax Ocellaria.

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BLATTA (*BLABERUS*) GIGANTEA

PLATE VII. Fig. 1.

Blatta gigantea.—*Linn. Fabr.*—Blaberus giganteus, *Serville.*—*Drury's Exotic Insects*, vol. ii. Pl. 36, fig. 2.

This is certainly the largest species of this family; the length of the body being frequently about three inches, and the wings when expanded often measuring half a foot from tip to tip. The general colour is a dusky livid; head reddish-brown; antennæ half the length of the body, and of a brown colour. The thorax, which is thin and flat, of comparatively small size, and of a transverse oval shape, has a large quadrate brownish-black spot in the centre. The tegmina, as well as the wings, are livid, the former appearing striated, and having a narrow brown streak on each, extending from the shoulder along the middle. Abdomen brown; the legs reddish-brown.

This species is a native of South America and the West Indian Islands. It has occasionally appeared in this country in the vicinity of harbours and docks, but can no more be regarded as a native than the bird-spider of America (*Mygale avicularia*), and other foreign visitors, which are sometimes found in such situations. This insect well represents the general form and appearance of the Blattæ, but there is a small section of somewhat dissimilar aspect arising from the back being rather convex, the colours deeper and more varied, with other less obvious differences. As an example of this modification of form, we have figured

B. PETIVERIANA.

PLATE VII. Fig. 2.

Linn. Fabr.—Blatta heteroclita, *Pallas, Spec. Zool.*—*Stoll's Blattes*, Pl. 5. *d.* figs. 21, 22.—Cimici affinis niger.—*Petiv. Gazop.* Pl. 71, fig. 1.

It is about ten or eleven lines in length, and of a dull black colour; antennæ about half the length of the body. The tegmina, when closed, overlap each other, and the upper one has four large spots of yellowish white, three placed longitudinally along the exterior border, the fourth smaller, and situate near the middle of the inner margin. The other wing case has only the three exterior spots, the central portion of the inner margin being of a fine reddish-yellow. The wings are very short, and seem scarcely fitted for flight. The abdomen above is rather wider than long; the colour black, with a small triangular fulvous spot at the side of each segment, and two small lateral appendages behind. Underside and legs black.

This insect, which is a native of the West Indies, was first figured by Petiver, one of our oldest British Naturalists, after whom it has been named.

FAM. MANTIDÆ.

This curious and interesting group will be easily recognised by the following summary of its most characteristic features. The head is long, triangular, and vertical, furnished with large eyes, (sometimes having a triangular prolongation in front,) and three

distinct stemmata; antennæ long, filiform, and slender, composed of numerous joints, sometimes pectinated in the males; terminal joint of the palpi ending in a point; ligula quadrifid; tegmina thin and reticulated, usually covering the wings, legs unequal, the anterior pair elongated, thickened, and armed with teeth; tarsi five-jointed.

This tribe includes a variety of very singular forms, which have received the name of *walking leaves*, from their resemblance in colour, form, and texture to these parts of vegetables. The veined and reticulated tegmina may even be said to represent the different states of leaves; in some appearing but partially developed, and in others assuming the variety of tints which characterise the different seasons. Thus they are in some fresh and green, and this, as in the foliage of plants, is the prevailing hue; in others they appear brown or rust-coloured, with the surface wrinkled and shrivelled, strongly resembling withered or decaying leaves. The likeness is frequently heightened by the foliaceous expansions of the legs, while the long narrow shape of these members, and also of the thorax and abdomen, assimilate them, in some measure, to twigs, footstalks, or small branches.

These insects are carnivorous, a disposition which might be inferred from the prominence of their eyes, size and shape of the mandibles, and their being fitted for rapid motion. They prey upon weaker individuals of their own class, and like most other insects of predatory habits, have a peculiar provision

for enabling them to secure their victims. One of the distinguishing marks of the present family is the great length and thickness of the forelegs, which, owing to the length of the thorax, usually appear remote from the other pairs, and placed near the head. They thus admit of being extended forwards considerable way from the body, and their structure admirably adapts them for seizing small objects. The thigh, which is the thickest portion, is grooved on its inner edge, and beset with a double row of strong spines; the tibia is so formed as to close upon it as the blade of a pocket-knife does upon its handle, and being likewise spinous on its interior edge, effectually secures any object that may be within, in a manner somewhat similar to what is practised by that carnivorous vegetable the *Dionea muscipula*. The efficiency of this implement is shewn not only in seizing small insects, which become an easy prey, but in the combats which the Mantidæ carry on with each other, for a dexterous application of it decapitates an opponent as expeditiously as could be done by a guillotine. In a leg so constructed, the tarsus becomes a very subordinate appendage, being short and weak, and apparently unequal to support the body, resembling that part in certain Coleopterous genera (such as *Phanæus, Geotrupes*, &c.) where it shews a tendency to become obsolete, as its functions are performed by the extremity of the tibiæ. These raptorial legs are often equal to the entire length of the body, and in some instances even surpass these dimensions.

They are usually borne extended before the insect, and frequently raised upwards, and clasped as it were together. This attitude led the ignorant to the fantastical notion that these insects can divine or indicate future events, and in many places they are regarded with a kind of religious veneration. The species which occurs most plentifully in the southern provinces of France (*M. religiosa*), is particularly famous for pointing out the road to children and others who happen to have lost their way. "Puero interroganti," says the credulous Rondelet, "de viâ altero pede extento rectam monstrat, *atque rare vel nunquam fallit.*" Another species is held in such high veneration by the Hottentots that the individual upon whom it happens to alight, is supposed to have a peculiar degree of sanctity imparted to him, and to be a special favourite of heaven. These superstitious fancies have suggested to systematic authors such names as oratoria, religiosa, precaria, pater noster, &c. It is scarcely necessary to state, that these movements are the result of the peculiar instinct and mode of life of these insects; for being fierce, cruel, gormandising creatures, so far from indulging, as has been fondly supposed, in a state of religious abstraction, they are continually seeking what they may devour. With this view, they are perpetually moving their arms or fore-legs in the air, and closing one armed joint upon another, so that whatever insect prey comes within reach, is immediately transfixed and consumed.* The following observations are

* Encyclop. Brit. 7th Edit. Entom. p. 190.

made by Dr. Shaw in relation to *M. viatoria,* but they are equally applicable to the whole tribe:—"In its real disposition it is very far from sanctity, preying with great rapacity on all the smaller insects which fall in its way, and for which it lies in wait with anxious assiduity, in the posture before mentioned, seizing them with a sudden spring when within its reach, and devouring them. It is also of a very pugnacious nature, and when kept with others of its own species in a state of captivity, will attack its neighbours with the utmost violence, till one or other is destroyed in the contest. Roësel, who kept some of these insects, observes, that in their mutual conflicts their manœuvres very much resemble those of hussars fighting with sabres; and sometimes one cleaves the other through at a single stroke, or severs the head from the body. During these engagements, the wings are generally expanded, and when the battle is over the conqueror devours his antagonist."

This pugnacious disposition is so strong in many of the species, that in China and other eastern countries, the inhabitants amuse themselves by making them fight like game-cocks. They are kept in small bamboo cages, and fed on soft skinned insects; and a set-to between these puny adversaries is said to be regarded with as much interest as a regular main at Fives-court.

The mantidæ are confined to the tropical and temperate regions of the globe. The former possesses by far the greater proportion of them, and it is only in the southern parts of the latter that they seem to

find a congenial climate. Europe is more sparingly provided with them than the other great divisions of the earth, having only a few species, and most of these of small size. One of these, however, (*M. Pagana*, a species not exceeding eight or nine lines in length,) is found as far north as Francfort on the Maine; but its occurence, even in a more northern latitude than this on the Continent, does not authorise us to expect to meet with it in our insular situation. We, accordingly, find that there is no representative of this family in Britain. They first become common in what has been called, in Zoological geography, the Mediterranean region, (including the southern coasts of France, Spain, Italy, Turkey in Europe, Greece, the coasts of Asia Minor, Syria, and the northern shores of Africa, as far as 30°,) which is characterised by numerous entomological peculiarities; and even here, though individuals abound, there is no great diversity of species. Many large and conspicuous mantes inhabit the East Indies and other parts of Asia; numerous species also occur in America, and not a few are found at the Cape of Good Hope. Among the latter is one of the smallest of the family, *M. Pusilla*, which scarcely exceeds the dimensions of Raphidia Ophiopsis;* some of the largest kinds,

* The resemblance of some of the smaller mantes to this neuropterous insect is not inconsiderable, and even a closer analogy may be traced between them and the genus Mantispa, the latter possessing falciform fore-legs, the want of which in Raphidia, forms the most prominent distinction in such a comparison. All of these insects have the unusual property of being able to elevate the thorax almost to a right angle with the abdomen.

upwards of four inches in length, occur in South America.

The eggs of the Mantidæ, which are very numerous, are enveloped when first laid in a soft substance, which, by exposure to the air, soon acquires the consistency of parchment. They are disposed, as in the family last described, in two rows; are of an elongated form and yellow colour. The packet is attached by an adhesive gum to the stalk of a plant.

As a generic designation, the term MANTIS is now limited to such members of the family as have the antennæ simple, head without an angular projection in front, eyes hemispherical, anterior legs long and falciform, the others slender and without spines. Many of them are of considerable size, and with a very few exceptions, extra-European.

MANTIS (*HARPAX*) OCELLARIA.

PLATE VII. Fig. 3.

Drury's *Exotic Insects*. Pl. 43. fig. 1.

HEAD and thorax yellowish brown, inclining to green; tegmina transparent at the tips, the remainder green, the centre of each marked with a yellow eye-like spot, encircled with black; wings transparent, the costa tinged with green; fore-legs yellowish brown; the middle and hinder thighs with a small expansion at the extremity, and two spurs on the tibiæ.

This handsome species inhabits the Coasts of Africa.

Mantis Religiosa

Lizars sc

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MANTIS RELIGIOSA.

PLATE VIII.

Linn. Roesel's Ins. ii. Gryll. Pl. 1. fig. 1. 2.—M. Oratoria, *Linn.*—*Roesel's Ins.* ii. Gryll. Pl. 2. fig. 5, and Vol. iv. Pl. 12.—M. Oratoria, *Fabr.*—Lichtenstein *Linn. Trans.* vi. p. 28.

THIS well-known species is about two inches in length, of a light green colour, inclining to brown in some places, and occasionally almost entirely of the latter hue; thorax elongate, particularly in the female, and smooth on the surface; tegmina as long as the abdomen, green and unspotted, each of them with a strong longitudinal nervure, at some distance from the anterior border; under wings of an elongate triangular shape, green anteriorly and of a firmer texture than behind, where the colour is pale white; the abdomen and legs are also green; the anal spines, as well as those on the anterior legs, deep chestnut. On the inner side of the coxæ of the fore-legs, there is a yellow spot bordered with black—a peculiarity which, according to Latreille, serves to distinguish this species from one nearly allied, which is a native of the Cape of Good Hope.

This species appears to be general throughout the Mediterranean region, and in many places it occurs in great profusion. It is the *M. prie-dieu* of the southern provinces of France and Italy. If the synonyms of authors were to be admitted as accurate, it should likewise be regarded as extensively distributed over foreign lands, but in many instances they

are certainly erroneous. Lichtenstein, for example, refers to this species two mantes figured by Stoll, one from Surinam, the other from Tranquebar, which have all the appearance of being distinct. It has now been demonstrated, that, in order to obtain just views of the geographical distribution of insects, as well as other tribes of inferior animals, more importance must be allowed to minute characters than they were thought to deserve by the older naturalists. Even with this limitation, however, there is no doubt that this species is widely spread.

MANTIS (*DEROPLATYS*) DESICCATA, *West.*

Plate IX.

This plate represents, of the natural size, a remarkable and unique insect, hitherto undescribed, belonging to the present family. The expansive membrane on each side of the thorax is one of its most remarkable characters. From its resemblance to a withered leaf, Mr. Westwood, to whom we are indebted for a figure and description, has distinguished it by the above name.

The length of the body is about three inches, the expansion of the tegmina three inches and a quarter. The colour is obscure brown variegated with dull red and buff. The eyes are large, lateral, and not acuminate; head unarmed. Thorax furnished on each side with a large and very thin membrane, (resembling a withered leaf,) having a deep dentate notch on each side behind. The margins of the abdomina

Lucas sc.

Deroplatys disiccata

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1 Empusa Gongylodes. 2 Empusa lobipes.

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segments are lobed. The tegmina are ornamented near the tips, beneath, with a large black spot surrounded by a white circle, which appears through the semi-transparent tegmina on the upper side; the posterior wings are very dark brown, the costa and tips being paler brown. The anterior femora are of a moderate size, shining beneath, with four short black bars at the base of the spines. The four posterior legs are slender, the thighs having a small membranous bifid lobe near the tips.

This insect, which must be regarded as a singular one even in the eccentric tribe to which it belongs, is a native of Malacca, and forms one of the ornaments of the extensive collection of the Rev. F. W. Hope. It enters into Serville's first section of the family, the four posterior thighs being furnished with a membrane at the tips; but the unarmed structure of the head and eyes will not allow it to be referred to any of the genera (or rather subgenera) which he has proposed; Mr. Westwood has, therefore, considered it proper to give it a new subgeneric name, founded on the dilated form of the prothorax, by which character it appears to connect Empusa and Chæradotes; Oxypilus also, having the head elevated in the middle, forms another link between the species with lobed and those with simple tibiæ.

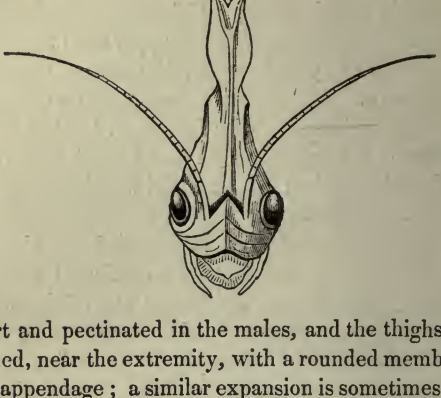
EMPUSA GONGYLODES.

Plate X. Fig. 1.

Latr. Serville.—Mantis Gongylodes, *Linn.*—*Roesel.* ii. Locusta, Pl. 7.—*Stoll. Mant.* Pl. 16, figs. 58, 59, 61.—*Fabr. Ent. Syst.* Drury's *Exotic Insects, by Westwood*, I Pl. 50, fig. 2.

This genus is distinguished from Mantis by having

the forehead produced like a horn, the antennæ rather



short and pectinated in the males, and the thighs furnished, near the extremity, with a rounded membranous appendage; a similar expansion is sometimes also found on the tibiæ. The species are among the most remarkable looking of this family, the limbs being very long and slender, and the thorax of such a length and so attenuated that the head and anterior legs appear to have but little connection with the hinder parts. Most of these insects are natives of Asia, the species figured on the adjoining plate is found in many parts of East India, but it is probably by mistake that Drury mentions Philadelphia as producing it. It is a pretty large insect, frequently measuring nearly three inches and a half. Head and thorax yellowish brown, resembling the colour of a withered leaf; the former terminating behind in a conical projection, bifid at the tip, with a slightly dilated membrane on each side; the latter very long and slender, (about half the length of the entire insect,) dilated behind the

head, and having an acute angle on each side. Tegmina yellow inclining to brown, especially towards the anterior margin, covering about two-thirds of the abdomen when closed; wings small, thin, and transparent, pale or light green. Abdomen yellowish brown, flat, much widened at the hinder extremity, and terminating behind in a triangular point, the sides waved and a little turned upwards. The anterior legs are nearly of the same colour as the head and thorax, slightly clouded with dark brown, the thighs very much thickened, and the trochanters, which are long, thin, and flat, terminating in a strong slightly curved spine; the other legs slender and greyish brown, each with a foliaceous expansion near the tip of the thighs, somewhat heart-shaped, and divided into two acute angles anteriorly; tibiæ of the middle legs terminating in three small spines, those of the hinder legs in two.

EMPUSA LOBIPES.

PLATE X. Fig. 2.

Mantis lobipes, *Lichen. Linn. Trans.* vi. p. 23.—M. undata, *Fabr. Stoll's Mant.* Pl. 8, fig. 30.

NEARLY as large as the preceding, to which it bears considerable resemblance. Head yellowish brown, triangular, the forehead much produced, the eyes round and very prominent; antennæ short. Thorax the colour of the head, half the length of the whole body, slender, margined on the sides, and a little dilated behind the head; tegmina longer than the abdomen, thin and transparent, wings hyaline, both slightly streaked with green rays; abdomen flat and

pretty broad. The anterior legs are long and thick, light brown clouded with dusky, the trochanters without a terminal spine; middle and hinder legs with a heart-shaped expansion near the apex of the thighs, and another of smaller size behind the middle of the tibiæ; the latter armed with two spines at the tip.

This insect is a native of Tranquebar and other places on the Coromandel coast.

Fam. Phasmidæ.

Although formerly confounded under the same name, the differences between Phasma and Mantis seem to be even more than generic, and sufficient to justify the establishment of two separate families. The spectres indeed, at first sight, appear to own but little connection with any other insect, their facies or general aspect being altogether peculiar. It is not till after a pretty careful examination of their structure that their relations become apparent. This is particularly the case with the apterous species, in which the essential characters appear, as it were, in such a disguise, that on a cursory inspection doubt may be entertained even about the order to which they belong. Some of the winged species, however, shew a more obvious affinity to the tribes with which they are usually associated.

This family is at once distinguished from the preceding one by all the legs being of equal dimensions, or nearly so. The head is large, rounded-oval, and usually borne somewhat horizontally; the antennæ

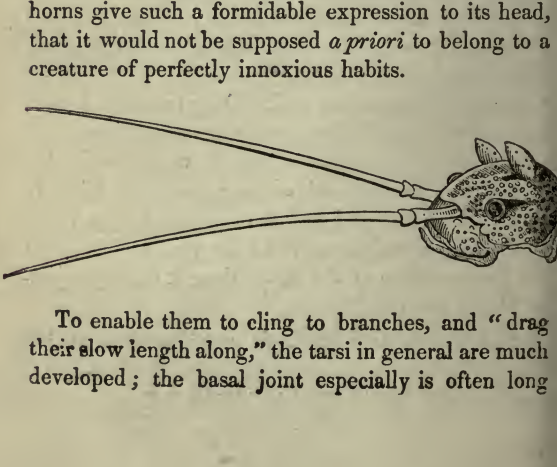
inserted before the eyes, seldom of great length, and the joints elongated. The tegmina are often wanting: when they exist they are short and narrow, never covering the hinder wings; the latter are often large, and not unfrequently ornamented with bright colours, a circumstance which generally takes place when the wings are not destined to be covered by a sheath. The prothorax is short, the body very long and linear.

These insects live exclusively on vegetable food. Their mandibles accordingly are of a different form from those of the mantidæ, and better adapted for gnawing. Like grasshoppers and locusts they lay their eggs in the earth, and for this purpose the females are provided with a small ensiform ovipositor .n the extremity of the abdomen, covered by three leaflets when unemployed. The eggs of some of the species are of considerable size, certainly among the largest to be found in this class of animals. Those of *Phasma dilatatum* are of a slightly oblong shape, flattened on one end. They are of a brown colour and marked all over with numerous impressed points, and have on one side a mark or double waved line so disposed as to represent a kind of cross. The flattened end is surrounded by a small rim or ledge, and seems to be the part which opens for the exclusion of the larva, since it readily separates from the rest.*

If not the most bulky of insects, some of the

* Linn. Trans. iv. pl. 18. fig. 4, 5.

Phasmidæ certainly surpass all others in length. Many of them measure half-a-foot from one extremity to the other, and one of them, (*P. gigas*) occasionally attains the length of about nine inches. The resemblance of the narrow bodied kinds to a small branch, is in many instances remarkably close, and this in connection with other peculiarities, is no doubt often the means of preserving them from the attacks of other animals. Were this not the case, they would fall an easy prey to their enemies, for they are ill fitted to act on the defensive, and the slowness of their movements affords but little chance of escape by flight. Among the other peculiarities alluded to, may be mentioned the spines with which many of them are beset, particularly on the head and thorax. As an example of this sort, *P. cornutum*, a large species, may be cited, whose frontal horns give such a formidable expression to its head, that it would not be supposed *a priori* to belong to a creature of perfectly innoxious habits.



To enable them to cling to branches, and "drag their slow length along," the tarsi in general are much developed; the basal joint especially is often long

and thick, and occasionally produced upwards in a conical form. The joint bearing the claws is likewise strong, and a large sucker is placed between the latter; suckers are likewise attached to the underside of the other joints, enabling the insects to secure a footing even where there are few or no inequalities on the surface.

The legs are seldom provided with leaf-like expansions among the typical Phasmidæ, although a tendency to that structure appears in *P. latipes* and some others. In the genus Phyllium, however, the principal species of which is so remarkable for its perfect similarity to a laurel leaf, the thighs and anterior tibiæ are both excessively dilated. The legs are frequently inserted at equal distances, (as in the genus *Cladoxerus*), at other times the middle and hinder pairs approximate. The forelegs being placed just behind the head, have a piece scooped out of the femora at the base, in order to afford room for its free movement.

The sexes of these insects may be distinguished by the males being much smaller than the females; their antennæ longer and thicker; the tegmina smaller, more pointed, and spined at the base. In the males also the forelegs are proportionably longer, thinner, and armed with fewer spines.

The phasmidæ are more decidedly tropical insects than the mantidæ. The intertropical regions of Asia, America, and the great islands of the Indian Ocean are the appropriate abodes of the largest and most remarkable kinds. Africa, Western Asia, and

Europe possess very few; in the last mentioned continent, indeed, only two species occur, and they are of comparatively small size, namely, *Bacillus Rossius*, and *B. Gallicus*, natives of Italy and the southern provinces of France.

One of the species is said to have been occasionally used as an article of food, and is hence named *P. edule*. The late Rev. Lansdown Guilding has made us acquainted with the singular fact, that if the larva or nymph of *P. cornutum*, happen to lose one of its legs, it reappears after the first change of skin following the accident, although it is always smaller than the opposite limb of the same pair.

PHASMA NECYDALOIDES.

Plate XI.

Lat. Gen. Crust et Insect. tom. iii. p. 87.—*Fabr. Stoll*, Pl. III. fig. 8; and Pl. IV. fig. 11.

This conspicuous insect affords a good example of the genus Phasma, as it has been restricted by Serville and St. Fargeau. According to these authors it is characterized by having the first joint of the antennæ cylindro-conic; the second globular; three large ocelli; the body cylindric, always provided with wings and tegmina (in both sexes); the thighs and tibiæ linear and simple. The general colour of P. necydaloides is greyish-yellow; eyes red; thorax with pointed tubercles; abdomen and posterior legs cinereous; the incisures and articulations brown. Tegmina small, pale brownish-yellow, with dark-brown nervures; exterior edge of the wings light-

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Phyllium siccifolia

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Native of Asia.

The drawing of the above very interesting specimen was kindly presented to us by Henry Hopkin White Esqr of Lincolns Inn after the volume had been printed off, consequently we have not been able to insert any account of it in the text at the proper place.

PHYLLIUM SICCIFOLIA or WALKING LEAF;

with the Eggs, compared and corrected from specimens in the British Museum; the Insect was brought from Mahe the principal place of the Seychelle Islands, N.E. of Madagascar, near the Equator, and one of them is broken, the yolk exhibiting a beautiful analogy to the seed of a vegetable.

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brown, the rest inclining to reddish-brown, variegated with transverse rays and spots of dull-white. The male is much smaller, and of a deeper brown.

PHYLLIUM SICCIFOLIA.

PLATE XII.

Mantis siccifolia, *Linn.*—Roesel II. *Gryll.* Pl. XVII. figs. 4-5. —*Stoll*, Spectres, Pl. VII. figs. 24-26.

This genus has the antennæ inserted before the eyes; no distinct ocelli; palpi compressed; prothorax nearly as long as the mesothorax; body broad and flat; the tegmina dilated and veined like leaves; all the thighs compressed, and having a broad membranous appendage before and behind; the tibiæ, when at rest, applied to the thigh beneath the dilated membrane; tarsi five-jointed.

Of the few species known, that represented on the adjoining plate is the largest and most beautiful. The female has the tegmina and upper portion of the abdomen of a fine green; the antennæ in this sex are short and obtuse. In the male the tegmina are comparatively small; the wings large and transparent, green on the anterior edge; the body narrow; the antennæ rather long and setaceous, composed of numerous cylindrical joints.

It is a native of Eastern Asia, Java, and the adjoining islands.

Having thus detailed the leading peculiarities of the first great division of this order, we now proceed to the second, containing the families of Crickets,

Grasshoppers, and Locusts. These differ from all the preceding tribes, in having the hinder legs lengthened and much thickened, in order to fit them for leaping. Besides this marked peculiarity in structure, there are others no less striking in their manners and economy. The males are musical, or, in other words, have the power of producing a stridulent note, apparently for the purpose of attracting the attention of the females. With very few exceptions they are herbivorous insects, and deposit their eggs in the earth. In general they frequent plants, but a few live in holes which they excavate in the soil.

Fam. Achetidæ.

Antennæ very long and slender, composed of numerous articulations; head generally large, thick, and somewhat rounded; tegmina lying nearly flatly along the back, and for the most part rather short; wings longer than the tegmina, and projecting behind the body: tarsi generally three-jointed.

The family of the crickets presents several variations in the possession or non-possession of ocelli. In Tridactylus there are three distinct ocelli; in the mole cricket only two are visible, the third being apparently obsolete, or, as Latreille says, "subobliteratus." In Myrmecophilus they are entirely wanting, and in the true crickets they are said by Latreille to be "subobsolete;" but this last statement needs modification. In the domestic cricket no trace of them can be detected; while in the new species figured a pair of these organs are very distinct, as they are

also, Mr. Westwood informs us, in several other allied undescribed species in his collection. The genus, in fact, seems to contain several groups quite as distinct as the section formed by Latreille (*Gen. Crust. &c. III.* 99,) for the reception of Acheta Italica, and of which Serville has composed the genus Œcanthus. A. Arachnoides may be regarded as forming a connecting link between Acheta and Phalangopsis of the last named author.

Typical examples of this family are to be found in the well known domestic cricket, field cricket, and mole cricket. The two former are referred to the genus Acheta, which, besides them, comprehends two other British species. The history of the domestic cricket has been so often given, that it is unnecessary to repeat the particulars in this place. It occurs in most of the other countries of Europe, as well as in Britain. Its song, if such it may be called, (for which it is so highly valued in Spain, that the peasantry sometimes hang it in little cages by the fireside,) is produced by a very simple piece of mechanism, and is peculiar to the male. It consists of a kind of rounded areolet, tense and shining, situate at the base of each of the tegmina; the latter overlap each other, the right being uppermost, and the left beneath it. The nervures of their dorsal portion are thicker, and form larger cells in the male than in the female.* When the former wishes to produce the sound, he elevates the hinder part of the tegmina in such a manner as to form an acute angle

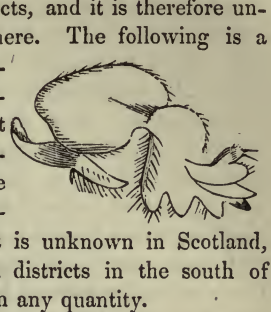
* See Pl. VI. figs. 8 and 9; the former is a dorsal view of the male cricket, the latter an under side view of the female.

with the body, and rubs them against each other with a brisk horizontal movement. The nervures on meeting each other produce the well known sound; the areolets at the base seem to serve no other purpose than to give intensity to it. M. Burmeister, however, advances another explanation of the phenomenon in question. According to him, the air upon being forcibly expelled from the stigmata, particularly those of the thorax, by the violent agitation which the animal imparts to its whole body, strikes against the lateral edges of the tegmina; but being unable to escape in that direction, it is forced to ascend, and comes in contact with the membranous areolets, which by being thus struck are thrown into a state of vibration. This may certainly contribute to the intensity of the sounds, but it is obvious from their nature, that they originate in a mechanical action rather than in the air issuing from the stigmata.*

The field cricket (*A. campestris*), presents a sufficient number of structural modifications, taken in connection with its mode of life, to justify the establishment of a separate genus for its reception. It is well known to reside in holes dug in the earth, where it lies in wait for insect prey. Although habitually carnivorous, it seems, however, capable of subsisting on vegetable substances; for Stoll affirms that he kept a pair alive for a considerable time by feeding them on grass and crumbs of bread. Another interesting insect of this tribe is the mole cricket (*Gryllotalpa vulgaris*) which has long attracted ob-

* Lacordaire's Introd. i. p. 275.

servation by the nature of its haunts, and the beautiful adaptation of its structure to its peculiar mode of life. Its history is to be found in almost every elementary work on insects, and it is therefore unnecessary to repeat it here. The following is a delineation of its anterior leg, which may be regarded as one of the most perfect examples of a fossorial instrument to be found in this class of animals. The mole cricket is unknown in Scotland, and it is only in certain districts in the south of England that it is found in any quantity.



Many different species of Achetidæ occur in foreign countries, and several of them exhibit very remarkable forms. The male of Gryllus umbraculatus of Linnæus, a native of Spain and Portugal, is remarkable for a membranous prolongation of the forehead, which hangs down in the form of a veil. G. Pattersonii, as represented by Stoll, has a singular inflation in front of the head, and two long horns curved forwards, and placed before the eyes. The species which the same iconographer names G. Vorax, has an enormous head with large projecting mandibles, and antennæ little short of half-a-foot in length.

As an example of this curious and well known family, we have represented an interesting species, now figured for the first time.

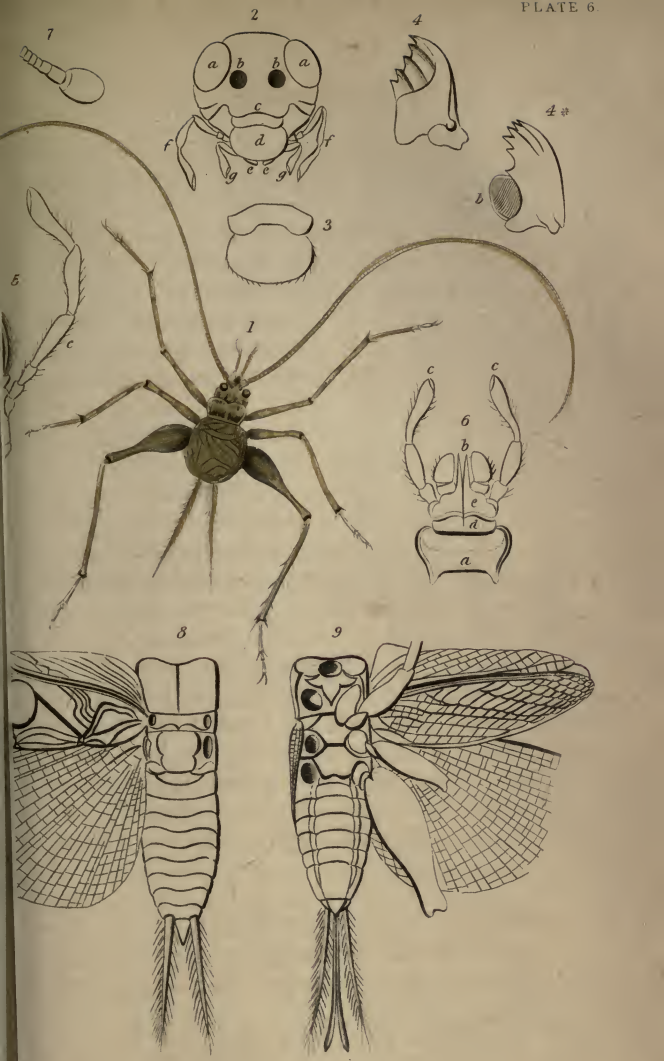
ACHETA ARACHNOIDES.

PLATE VI. Fig. 1.

IT is a native of Jamaica, and specimens are preserved in the collection of the Entomological Club of London. From its peculiar form and resemblance to a spider, Mr. Westwood has given it the specific name of *Arachnoides*. It is about seven lines in length, exclusive of the anal filaments, of a yellowish hue, variegated with dusky brown. The head is transverse, produced in front, between the antennæ, into an oblong black hirsute point; of a dull clay colour, with dark brown markings. Two ocelli are distinctly visible near to and behind the insertion of the antennæ. The latter are very long and multiarticulate; the palpi likewise long and slender, with the terminal joint very slightly securiform. The thorax is transverse, dull clay coloured, varied with brown the tegmina short, the dorsal portion of each forming nearly a circle, of a dull reddish clay colour, with the basal portion darker. The legs are of great length, of a dirty ochre yellow, with the four anterior thighs and tibiæ ringed with brown, the anterior tibiæ furnished with a minute talc-like spot at the base. The antennæ and anal filaments dirty clay colour.

FAM. GRYLLIDÆ.

THIS family comprehends the extensive tribe of grasshoppers, which have often been confounded, both by popular and scientific writers, with the true locusts



1 Acheta Arachnoides.
8.9. Upper and underside of the
thorax and abdomen of the Domestic cricket

Lizars sc.

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It must be admitted, indeed, that a very intimate connection exists between them, and it is only by attending to peculiarities which do not greatly influence the general appearance, that the distinction can be manifested. The Gryllidæ have very long antennæ, always as long as the body, and frequently of much greater length; setaceous or nearly filiform, and consisting of numerous indistinct joints, often upwards of a hundred. The tarsi are four-jointed, and the females are provided with a very long compressed ovipositor, which projects from the hinder part of the body, and is usually somewhat curved upwards. The resemblance the shape of this instrument bears to a sabre or cutlass, has led some Continental writers to name these insects *Sauterelles à sabre*. The head is perpendicular or slighly incurved, and the tegmina are deflexed, partially embracing the abdomen.

All these insects are herbivorous, the greater part of them feeding on grass and herbaceous plants, but not a few of them prefer the foliage of trees. They have been observed not to refuse animal food when accidentally placed in their way, but this has happened but rarely, and must be regarded as a violent deviation from their natural habits. They frequent meadows, pasture lands, and rocky declivities exposed to the sun, intimating their presence by an incessant chirping, and by leaping among the feet of the passenger. Very few of them inhabit this country, and such as we possess are, with one exception, of insignificant dimensions, contrasted with those of many foreign lands. Many finely coloured species are found

in Surinam, and other parts of America, as well as in Africa and Asia. In some of them the tegmina and wings are of great amplitude, and the powers of flight are probably considerable; they are likewise ornamented with rich colours, frequently rendering them very ornamental objects. The similitude, of these parts, to the leaves of trees, formerly mentioned as signalising the Orthopterous order, is also conspicuous in the present tribe, particularly in that section of it, which, in allusion to this very circumstance, Kirby has proposed to name *Pterophylla*, or leaf-wings.

Grasshoppers deposit their eggs in the earth, an operation which they accomplish by means of the lengthened ovipositor, which forms one of their distinctive features. This instrument is slightly modified in form in the different genera. In Acrida, it consists of six pieces or valves, two upper and four lower, each of which is grooved internally, and these are moved backwards and forwards alternately, when employed in boring. The eggs are rather long, and narrowed at both ends; they are laid in considerable quantities at a time, and extruded together along with a kind of mucous matter, which soon dries and becomes a slender membranous envelope. The nymph or pupa does not differ from the larva, except in bearing on the back a pair of rudimentary wings, enclosed in a kind of sheath. The larvæ and pupa are, of course, incapable of flight, but the mature insect springs into the air with great facility, and expanding its capacious wings, can sustain itself for a

considerable time. In ordinary cases, they traverse but short spaces at a time; but when any change of place becomes requisite, they are able, like their relatives the locusts, to fly both high and far. Indeed, it is very probable that the relations given by travellers respecting the immense congregations and flights of what are vaguely termed locusts, ought sometimes to be referred to certain kinds of Gryllidæ.

Although these insects do not leap so powerfully as the true locusts, the structure of the hinder legs, the instruments by which they accomplish it, is precisely similar. The thigh is much elongated, and thickens gradually as it approaches the body; the knee is likewise a little swollen to afford room for the somewhat complex articulation which unites it to the tibia. Along each side of the thighs, are three longitudinal ridges, and on the upper and under sides, a double row of quadrangular elevations, placed obliquely, and somewhat resembling the surface produced by plaiting together two pretty broad thongs. What may be called the knee-pan, has a cavity in the centre, adapted for the reception of the head of the tibia, and in this sinus the condyle of the tibia works. Besides the central process or condyle of the tibia, there are two lateral ones which also work in a sinus of the knee. The motion of the tibia is therefore semirotatory up and down, as upon a pair of pivots, and all the parts being connected by means of strong ligaments, dislocation cannot easily take place. When this is considered in connection with the state of the muscles of the thigh, thickened for

the express purpose of securing an increase of power, we perceive how admirably adapted these creatures are for a kind of motion which must often have excited surprise by its extent and rapidity.

The tibiæ are thickly armed with spines, some of which are merely processes of the crust, and others are implanted. Of the former there are two rows, one on each side, leaving a groove between them; and of the latter are those on the lower angles of the tibiæ.

Of this family we shall figure, as examples, two British species, and a few remarkable foreign forms.

ACRIDA VIRIDISSIMA.

PLATE XIII. Fig. 1.

Gryllus viridissimus, *Linn.*—*Donovan's Brit. Ins.* IV. Pl. 130.
Locusta viridissima, *Leach.*—Conocephalus virid. *Samouelle.*—*Curtis' Brit. Ent.* I. 82.

ACRIDA has antennæ as long as the body, setaceous, the basal joint dilated, second short, third rather longer; maxillæ with three small teeth at the tip, the palpi having the terminal joint longest and truncate at the extremity; labrum orbicular, dilated at the base; mentum narrowed anteriorly; the exterior lobes of the ligula dilated and palpiform; posterior tarsi with the penultimate joint short and bilobed, the first having a lobe on each side near the base.

This genus contains all the British insects that can be referred to the family of the Gryllidæ. Although they do not exceed a dozen, they are so diversified in character that it is only by a pretty general definition that they can be comprehended in the same generic

PLATE 13.

Acrida viridissima, Britain

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group. Some have the wings and tegmina perfect, others are apterous; in some the males have an ocellus at the base of the tegmina, in others it is wanting; the mandibles of certain species are short, trigonate, and almost entire on the inner edge, while others have them long, acute, and dentate; finally, the ovipositor is sometimes curved and sometimes straight.

ACRIDA VERRUCIVORA.

PLATE XIII. Fig. 2.

Gryllus verrucivorus, *Linn. Fabr.—Roesel* II. *Gryll.* VIII.

THIS handsome and not uncommon species, is nearly an inch and a half in length, the general colour green, with dark brown spots on the tegmina, and a few smaller ones on other parts of the body; the ovipositor of the female curved. It has obtained its name from a belief said to have once prevailed among the Swedish peasantry, that its bite and the black liquid which it disgorges into the wound were useful in removing warts. It is said to have occurred in this country: on the continent it is not rare.

PTEROPHYLLA OCELLATA.

PLATE XIII. Fig. 3.

WE here figure what Stoll regards, seemingly with propriety, as a variety of the *Gryllus ocellatus* of Linnæus, belonging to a remarkable group, at once distinguished from all others by the amplitude of their tegmina and wings. In its ordinary appearance the tegmina very much resemble a dry leaf, the disk inclining to a purplish colour; in the variety represented

the tegmina simulate a leaf beginning to decay, the extremity and nervures being brown, the remaining parts yellowish green. The wings are pale brown and transparent, with transverse undulating dusky streaks, each having a large ocellated spot at the extremity, consisting of a black ground with two white crescents, the exterior edge reddish and surmounted by a black streak.

The remarkable looking insects of this genus, which might at first sight be taken for Lepidoptera, are natives of Surinam and Guiana.

ANOSTOSTOMA AUSTRALASIÆ.

PLATE XIV.

THE figure referred to represents a very remarkable apterous insect of this family, from a drawing by Mr. Westwood, taken from the specimen in the collection of the Rev. F. W. Hope. It is a native of New Holland, and was first described, a short time since, by Mr. Grey, in the Magazine of Natural History.* It was brought from the interior, 300 miles up the country. It is almost entirely of a ferruginous colour, the abdomen variegated with yellow; legs brownish yellow; length, including the mandibles, two inches and a half. The head is very large; labrum prominent and crescent-shaped; ocelli three, not placed at the base of the ridge between the antennæ, (as described by Mr. Grey,) the anterior one being considerably in front of it, and the posterior pair at its

* New Series, vol. I. p. 143.

J.O. Westwood. del.t

Anostostoma Australasiae.

New Holland.

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hinder part: mandibles very long and toothed at the extremity; palpi very long and slender, composed of long joints, the maxillary pair terminated by a fleshy wart, (not an acute spine, as stated by Mr. Grey;) legs long, especially the hinder ones, the thighs of which are much thickened; tibiæ strongly spined; tarsi four-jointed, but having a fleshy lobe at the base of the radical joint on the under side, by which character it is associated with the present family, and not with that of which we are next to speak.

Fam. Locustidæ.

Antennæ short, seldom exceeding half the length of the body, filiform or subulate, sometimes thickened towards the middle or extremity, the joints generally distinct and not very numerous; tarsi three-jointed; abdomen conical and compressed, the female without projecting ovipositor. The males are without a circular spot at the base of the tegmina, and their stridulent note is therefore entirely produced by the friction of the thighs against the tegmina and wings.

Such, concisely, are the most marked distinctive features of a tribe of insects which have long been objects of historical celebrity on account of their extensive depredations. As they are very numerous, and present considerable differences in external characters, the genera into which they are divided are necessarily many. The ravages of locusts have been often described, and the accounts given by travellers of their astonishing multitudes and powers of destruction are calculated to excite our astonishment. It is also

well known that in most of the countries where they occur they are more or less used as food, and this practice was probably even more common in ancient times than at present. The mode of preparing them varies in different places. The Bedouins of Egypt roast them alive upon the coals; in addition to this the Arabs steep them in butter. The inhabitants of Morocco dry them on the roofs and terraces of their houses, and eat them either smoked or broiled, and esteem them so highly that the price of provision falls when the locusts visit the neighbourhood. The Hottentots, as well as many Arabian tribes, dry them, and grind them into a kind of flour of which they make bread. In consequence of their being used for these purposes, the markets and shops in many places are supplied with them, and they are sold at a low rate. They are also used by the Hottentots to feed fowls, which eat them with avidity. The Calmucks feed sheep, antelopes, and other animals with them; and when swarms are drowned in the Volga and cast on shore, hogs eat them eagerly and become unusually fat on the diet.

LOCUSTA MIGRATORIA.

PLATE XV. Fig. 1.

Gryllus Migratorius *Linn. Fabr.*—*Roesel's Insects*, ii. *Gryll.* xxiv.—*De Geer*, iii. p. 466, Pl. 23. *f.* 1.

THIS species occasionally attains the length of two inches and a half; the thorax is slightly ridged, and faintly marked with a transverse line, the colour greenish or dull-red, with a longitudinal black spot on each side; tegmina brown, with darker spots;

Locusta migratoria. Egypt.

Lizars sc

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Lizars sc

1.Locusta cristata. 2.Locusta flava.

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wings transparent, tinged with green at the base; abdomen testaceous; hinder thighs angular, and spotted with black on the inner side; tibiæ red. Found abundantly in Egypt, Barbary, and in the south of Europe; occasionally extending as far north as Paris, and even Britain.

LOCUSTA DUX.

PLATE XV. Fig. 2.

Gryllus Dux, *Linn. Fabr.*—*Drury*, Pl. XLIV.—*Encycl. Method.* No. 4, (*Acrydium*).—*Serville's Revis. Orth.* 92.

ONE of the largest migratory locusts known; the tegmina often measuring eight or nine inches from one extremity to the other. The head is dull-yellow, with an olive tinge: the thorax dusky-olive, ridged on the sides, and having an elevated dentate ridge down the back; tegmina dull-green, with numerous ill-defined dark spots; wings red, with a black edge, and parallel rows of black spots, most of them resembling the beards of arrows: abdomen olive-green or yellowish; legs red; the thighs chequered with white. A native of tropical America.

LOCUSTA CRISTATA.

PLATE XVI. Fig. 1.

Gryllus Cristatus, *Linn. Fabr.*—*Roesel's Insect.* tom. ii. *Gryll.* Pl. 5, figs. 1, 2.—*Stoll's Sauterelles de passage*, Pl. 9 *b.* fig. 30.

A LARGE species, sometimes measuring nearly four inches in length. Head and eyes brown; thorax olive-green, ridged along the back, and marked with four transverse impressions: tegmina greyish-green,

variegated with numerous small light-yellow quadrate spots; wings blue, with black spots, the posterior margin black; abdomen red above with yellow spots, yellowish-green beneath; hinder legs green, the thighs spotted with white. A native of South America.

LOCUSTA FLAVA.

PLATE XVI. Fig. 2.

Gryllus Flavus, *Linn. Fabr.*—Acrid. nigrofasciatum, *De Geer*, iii. p. 493, Pl. 41, fig. 5.—*Stoll's Sauterelles de Passage*, Pl. 11 *b*. fig. 41.

BODY ash-coloured; thorax unequal, with a dorsal ridge; tegmina clouded with rusty-brown, each with two light-coloured bars; wings of a fine yellow at the base, beyond this there is a curved band of blackish brown, the extremity transparent and unspotted; posterior thighs bluish-black internally; tibiæ red. Found at the Cape of Good Hope.

LOCUSTA SURINAMA.

PLATE XVII. Fig. 1.

Gryllus Surinamus, *Linn. Fabr.*—*De Geer*, iii. p. 503, Pl. 42, Fig. 3.—*Stoll's Saut. de Pass.* Pl. 22. *b*. 42, 42 A.

LENGTH from eight to nine lines; thorax black, with four longitudinal yellow lines; tegmina dull-green, inclining to grey; wings blue, very glossy; abdomen greenish-yellow, with a series of yellow spots on each side; thighs blood-red at the base, the tip, and sometimes a band near the middle, black. Found in Surinam.

1 Locusta Surinama 2 Truxalis conicus 3 Truxalis brasiliensis

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TRUXALIS CONICUS.

PLATE XVII. Fig. 2.

Gryllus Locusta Conicus. *Stoll's Saut. de Pass.* Pl. 23. *b.* Fig. 88.

THIS singular genus is at once known by the narrow conical head, which is longer than the thorax; and by the antennæ, which are ensiform and prismatic, as long as the head and thorax taken together, multi-articulate, and inserted between the eyes at the extremity of the head; the body long and narrow; legs slender and lengthened. The species, which are not numerous, and by no means accurately distinguished, are peculiar to warm climates, and we know scarcely any thing of their manners. The figure referred to above, may possibly represent a variety of *T. Nasutus*, although Stoll, from whom we have copied it, regards it as distinct. The thorax and tegmina are brownish yellow, the latter with a crenated whiteray along each; abdomen marked with yellow and black spots; legs brown. Fig. 3d, of the same Plate, represents a species named *T. brasiliensis* by Drury. It is closely allied to T. nasutus as well as T. conicus. The tegmina are pale fulvous, with a green stripe along the centre of each, irregularly indented on the hinder edge with black; wings transparent, the basal portion tinged with a delicate and beautiful red. Its habitat is Rio Janeiro, Brazil, &c.

ORDER III.—HEMIPTERA.

THIS is one of the orders provided with a mouth

formed for sucking. We have already described the oral tube of Butterflies and Moths, the only tribes so provided to which we have had occasion to advert. In the others, it presents a very different appearance, and likewise performs functions to which it is not adapted in these. Considered in relation to this important structural peculiarity, the Hemiptera would require to be associated with the other orders similarly distinguished; but an arrangement which assumes the organs of flight as its regulating principle, points out the situation now assigned to it as the most natural and appropriate.

These organs deviate still further from the wings of the Coleoptera than those of the order last described. The upper pair may be considered as divided into two parts; the anterior portion stiff and corneous, resembling elytra, the terminal portion membranous and more or less transparent. Hence the name Hemiptera or half-wings, (from ημιου the half,) and also hemelytra, the latter used to designate the upper wings when spoken of by themselves. This structure, however, must be looked upon as merely characterising certain typical species, for the deviations from it are numerous and important. The extent of the horny portion of the hemelytra is liable to great variation in different genera. In most instances, it occupies about a third part of the surface, sometimes the half, (as in *Lygaeus*,) at other times two-thirds, (in *Alydus*,) and three-fourths in certain *Reduvii*. Occasionally, it is so extensive as to reduce the membranous portion to a narrow band at the tip,

and in a numerous race it may be said to occupy the whole surface, rendering the hemelytra very similar to the tegmina of Orthoptera. On the other hand, the transparent portion often encroaches on the region of the other, to a greater or less extent, and in Coreus, Tingis, Aphis, &c., the whole is nearly of a uniform membranous consistency.

This want of uniformity has occasioned difference of opinion among authors respecting the position, affinities, and constitution of the Hemipterous order. Linnæus confounded it with the Orthoptera; others, in order to avoid the impropriety of associating gnawing insects with suctorial ones, effected their separation; and thinking it also improper to unite such as have half membranous upper wings with those in which they are wholly coriaceous, formed two separate orders under the names Hemiptera and Homoptera. This was done by De Geer, in which he was followed by Dr. Leach and Mr. MacLeay. Although the differences in the texture of the wings are certainly important, and it has the appearance of inconsistency not to take them into account in an arrangement where they are professedly assumed as indicating primary sections, more especially when they are connected, as in this instance, with corresponding differences in economy, it has notwithstanding been generally thought inexpedient to admit the separation alluded to. The transition from a corneous to a membranous texture, is certainly so gradual, that it would be difficult to fix where the line of demarcation should be drawn; all the species agree in the

important character of having a sucking instrument with a jointed sheath, and it must be admitted to be highly inadvisable to multiply orders except for the most urgent reasons. But if rejected as primary groups, they must be adopted as secondary ones; and we shall accordingly follow Latreille, who has, from this circumstance, divided this order into two great sections, which he denominates Heteroptera (wings of different texture) and Homoptera, (wings of uniform texture.)

The under wings are usually not of large size, and offer nothing peculiar in their forms and composition. When at rest they are covered by the hemelytra, being simply drawn beneath them, and more or less crossed, but without forming distinct longitudinal or transverse folds. Several species of Hemiptera are entirely apterous.

This is the only order in which upper wings of a rigid consistency coexist along with a mouth formed for sucking. The latter differs considerably from the spiral tube of butterflies and moths, which is a mere canal for conveying the nutritive fluids into the esophagus; besides serving this purpose, it is so formed that it acts as a lancet for piercing the integuments of plants and animals. As great length would scarcely be compatible with such a usage, it seldom equals the dimensions of a lepidopterous proboscis, being usually much shorter than the body. There are a few exceptions to this rule, however, and in some examples it is so long as to project a good way behind the body like a caudal filament. Although so different in ap-

pearance and use from the mouth of gnawing insects, it is found to be composed of the same or corresponding parts, with the exception of the palpi, which are quite obsolete. These parts, however, have, of course, undergone great modifications, to such a degree, indeed, that it is exceedingly difficult to recognise them. It is only from their insertion and position relatively to each other, that any agreement can be inferred; and, at most, the oral organs of suctorial species can only be considered as analogous to or representative of the parts of a mouth formed for mastication. There is reason to believe that some of the ingenious observers, who have turned their attention to this subject, have carried their views rather too far, from a wish to demonstrate a certain uniformity of organisation among different tribes—an interesting inquiry, but one which requires to be pursued with great caution, as the fancy is so apt to lead us astray. At all events, we have been often led from this cause to the application of names, which, however significant as originally used, becomes quite inappropriate in their present extended acceptation. The term mandibles, for example, is sufficiently descriptive of the gnawing organs of the mandibulata, but is wholly unmeaning when applied to a slender filet composing a portion of a tube, in which both the form and the function are completely changed.

The rostrum, when not employed, is bent beneath the breast, to which it is closely applied, passing between the legs. It consists of four joints, generally distinctly marked, of a cylindrical form, or tapering

to the extremity. The sheath, or external articulated portion, is formed by the elongation of the labium or lower lip, and is liable to little variation, except in length. Savigny seems to regard the basal segment alone as representing the true lip. It encloses four slender hair-like pieces, dilated a little at the base, and finely denticulated at the extremity. Of these the superior pair represent the mandibles, and the others the two blades of the maxillæ. They are incapable of horizontal motion, and the latter are destitute of the jointed appendages which they always bear in masticating tribes.* Over the base of the rostrum is situate the labrum or upper lip, of a conical shape, and usually very much lengthened, pointed, and frequently transversely striated. Immediately beneath this is sometimes observed another piece of similar form, which Latreille regards as analogous to the epipharynx, and also another portion which should be considered as corresponding to what he calls the hypopharynx. The clypeus is frequently distinct and conspicuous; the reverse is the case with the lingua or tongue, although Savigny has occasionally detected its presence.

The anterior part of the head is sometimes very much produced, forming a long beak, occasionally furnished with spinous projections. This is the case with the Fulgoræ, and in a well known species of that tribe, it is inflated into a large mitre-shaped appendage of a very remarkable appearance.

* Faint traces of palpi are said to have been observed in Thrips and Nepa.

The composite eyes present nothing very peculiar in this order. In general they are rather of large size, and at times placed very prominently. In the genus Aleyrodes there appear to be a pair on each side. Stemmata exist in most of the genera, but in some no trace of them can be observed. They are of remarkable size in Reduvius, almost equalling the dimensions of composite eyes, and seem to be wanting in Naucoris, Notonecta, Nepa, and some other tribes. When two in number, (which is frequently the case among the Hemiptera,) they are sometimes placed rather behind the eyes, at other times on the crown of the head, (as in Cercopis, Ledra, &c.) and occasionally (as in the Fulgoridæ,) between the eyes and the antennæ. In the genus Jassus they present the singular anomaly of being placed under the head. Sometimes they are remote from each other, (Scutellera, Edessa, &c.) at other times with their edges almost touching, (Reduvius, &c.) In shape also they offer some differences, the usual round form being exchanged, in Fulgora serrata, for an oblong with a longitudinal impression; in another example of the same genus, (Fulgora diadema,) the depression is circular. In the genus just named, the ocelli deviate in another respect from their ordinary appearance, being, instead of the usual black or hyaline colour, of a fine yellow in F. laternaria, and white in F. candelaria. In some kinds of Cicadæ they are red.

The antennæ vary greatly, as will appear from the descriptions afterwards given of them as aiding in distinguishing the different families. In the homop-

terous tribes they are usually very inconspicuous, sometimes so small as almost, on a general view, to escape observation. This is the case with Fulgora, Nepa, Ranatra, &c. in which they are short and subulate, and, being placed beneath the eyes, only become visible when the insect is reversed. In the heteropterous section, however, they are often of considerable length, and, in not a few instances, some of the joints are suddenly and broadly dilated. The articulations vary in number from two to eleven.

In the majority of insects the head articulates immediately with the thorax without any posterior elongation, but numerous examples occur in this order of a distinct neck. Certain species of the Cimicidæ have it so much elongated that the head appears placed upon a narrow peduncle.

The prothorax is, for the most part, very much developed, but a gradual diminution can be traced among the genera till it become a mere collar. It reaches its maximum among the heteroptera, and is usually much contracted among the homoptera. It is chiefly remarkable for the singular projections which frequently rise from it, rendering the species the most extraordinary looking insects with which we are acquainted. It is very often produced laterally into two long spines, which are sometimes truncated, at other times pointed, sometimes directed forwards, at other times curved backwards. Instead of spines, these projections occasionally assume the form of foliaceous appendages, notched or serrated on the edges. In Ledra they have the appearance of ears,

(*Ledra aurita,*) and, from the curious aspect they give to the Centroti, these insects are called in France *petits diables* and *demi-diables*. It is the prothorax that forms the large foliaceous expansion covering the whole upper surface of the Membraces, an extraordinary structure to which we are unable to assign any use, and which, as has been remarked, seems created by nature only for the purpose of shewing her inexhaustible fecundity in varying animal forms.

The metathorax is sometimes of considerable size in the Heteroptera. The scutellum is often so large as to form a very marked feature in the appearance of these insects, covering the whole of the surface of the abdomen, and protecting the wings like an elytron. On the other hand, it is minute in Cicada and the allied genera, and difficult to determine, presenting at times the form of a St. Andrew's cross, and somewhat forked posteriorly. In Fulgora it is triangular, while in Centrotus, Membracis, and some other genera, it is linear and transverse.

The legs present numerous variations in different species, as will appear from the descriptions subsequently given. These variations in the locomotive organs are rendered necessary by their diversified habits and modes of life. In such as inhabit waters they become adapted to oar the body through a resisting medium, and in those that prey on their fellows they undergo such a change as to be convertible into instruments of prehension. Even in those cases where they are entirely terrestrial and apparently of similar habits, the legs frequently differ both in their relative

proportions and in the amount of the componen articulations. In some the legs are nearly equal, i others the hinder pair have the thighs very muc lengthened, thickened, and armed with spines. Rap torial fore legs are formed nearly in the same manne as formerly described when speaking of the predace ous Orthoptera. They exist in the aquatic gener (*Hydrocorisæ*), and also in some terrestrial kinds such as the Syrtes, in which they terminate in monodactyle claw like those of some of the Crustacea The thighs sometimes serve to distinguish the sexes being, in many species of the Cimicidæ, dilated i the male, and of the ordinary size in the female. Th hinder tibiæ sometimes present the peculiarity o being furnished with very broad foliaceous expansions irregularly toothed on the edge; in some instance as wide as the body, and strongly contrasting with i by being of an entirely different colour. Such broa surfaces exposed to the air must exercise consider able influence on flight, and are probably of servic in balancing the body. The number of joints in th tarsi varies from one to five, but when the latte amount occurs it is not in all the tarsi, there being no example of a strictly pentamerous species in thi order. Several kinds are heteromerous, that is, having four joints in each of the four anterior tarsi, and five in the posterior pair. In Ranatra the number o joints may be represented by 2, 1, 1; and in Sigara and Naucoris, by 1, 2, 2. The great majority, how ever, have three joints in all the tarsi. Belostoma and Notonecta have two, a number of rare occur

ence; and Nepa has only one, of which but few ther instances are afforded by the class.

The general forms and relative position of the parts lescribed, will be well understood from an inspection f Plate XVIII. which represents the details of a haracteristic example of each of the two great divi- ions of this order.

Fig. 6 is a highly magnified view of an insect belonging to he heteropterous section, *Pentatoma rufipes*, a common Brit- sh species. The wings on one side are expanded, the others *n situ*. For greater perspicuity, the various segments, where overed by superincumbent organs, are represented by dots. H, the head; *a*, *a*, the eyes; *b*, the ocelli; *c*, one of the an- ennæ; T 1, upperside of the prothorax; *l'* one of the pro- horacic legs; T 2, upperside of the mesothorax; S c, scutel- um greatly developed and extending over the metathorax nd part of the abdomen; *h*, one of the hemelytra; *hc*, he leathery basal portion of the hemelytra; *hm*, the mem- ranous or apical portion; *l''* one of the mesothoracic legs; T 3, pper side of the metathorax, greatly reduced in size, sup- orting the wings (one of which is extended, W 2), and the ietathoracic or third pair of legs *l'''*—A, abdomen.—Fig. 7. 'he head and prothorax of the same insect seen from beneath; , the eye; *c*, base of antennæ; *lr*, labrum or upper-lip, long, id transversely striated; *lb*, the four-jointed lower-lip trans- rmed into an elongated canal for the reception of four slender tæ, *gg*, *hh*, which represent the mandibles and maxillæ; raised portion of the underside of the head, forming a gutter, which the base of the labrum rests; T 1, underside of the rothorax; *l'* base of one of the prothoracic legs; Z, the cavity the prothorax, into which the anterior narrowed part of the esothorax (marked in fig. 6 by the letter *z*) is received.— g. 8. Side view of the head, the respective parts lettered as in . 7.—Fig. 9. One of the anterior tarsi of Pentatoma rufipes, ewing the emargination at the base of the tibia, and the pul- lli attached to the base of the claws.

Figures 2-5 illustrate the structure of one of the homoptera *Cicada atrata*, a native of China.—Fig. 2. The head seen in front; *a*, *a*, the eyes; *b*, the three ocelli; *c*, *c*, the antennæ; *d*, the clypeus; *e*, the labrum; *f*, the labium, forming a sheath for the reception of *g*, *g*, the hair-like mandibles, and *h*, *h*, the hair-like maxillæ.—Fig. 3. Part of the mouth; *d*, the clypeus; *c*, the labrum; f′ f″ f‴, the two basal, and part of the long terminal joint of the labium.—Fig. 4. The seven-jointed antennæ.—Fig. 5. Underside of the thorax and abdomen; T 1, prothorax; T 2, mesothorax; T 3, metathorax; A, abdomen

We have already mentioned the comparative extent of the different orders, from which it appears that the one now under consideration is the fourth in the scale, nearly 25,000 species being supposed to exist. Rather more than 600 different kinds have been found in Britain; but most of these are inconspicuous insects of small size and obscure colouring.

The metamorphoses of these insects may be described as merely a series of moultings. The larva and pupæ are alike active, the latter distinguishable from the former only by having two small projections on the back which conceal the wings and wing-covers. The only perceptible difference in apterous species in their various stages, is that arising from size.

In proceeding to illustrate this order by a selection of a few species from the numerous tribes it contains, we shall first advert to that section which has been named,

HETEROPTERA,

The distinguishing marks of which it may be of advantage briefly to recapitulate in this place. The

1 Ægo Dispar 2 Pentatoma rutilans 3 Zoophi aster imperialis

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rostrum takes its origin directly from the front of the head; the hemelytra are always membranous at the extremity; the prothorax is much larger than the other divisions of the trunk; the body flat and depressed, the hemelytra and wings being always horizontal or very slightly inclined; the former crossing each other when closed; antennæ usually rather long and not terminating in a bristle; scutellum large; ovipositor not developed. This section contains the following families: Cimicidæ (*bugs*), Pentatomidæ (*plant bugs*), Coreidæ, Reduviidæ (*wheel bugs*), Acanthidæ, Hydrometridæ (*water bugs*), Nepidæ (*water scorpions*), Notonectidæ (*boat-flies*). The three last are aquatic, and the two last constitute the subdivision named *Hydrocorisa*, or water-bugs, by Latreille; the others form his subdivision *Geocorisa*, or land-bugs.

SCUTELLERA DISPAR.

PLATE XIX. Fig. 1.

Stoll's Punaises, Pl. 37, fig. 260.

This genus is essentially characterised by the excessive development of the scutellum, which covers the entire abdomen like a shield, concealing both the hemelytra and wings. As in all the other species of the family the antennæ are five-jointed, the joints pretty long and nearly of equal thickness; sucker consisting of four distinct articulations; tarsi three-jointed.

The scutelleræ were referred by Linnæus to his great genus Cimex, and they were subsequently con-

founded with Pentatoma, till Lamark effected their separation. The peculiarity which has occasioned this separation, is necessarily accompanied with some others which render them very distinct. As the scutellum is placed over the wings, it must be sufficiently elevated not to prevent their movements, and this gives the body a much more convex and rounded appearance than among the other tribes, sometimes, indeed, it seems quite gibbous. They invariably live on plants, extracting the juices from the more tender parts, where they are able to introduce their sucker. No example of the genus occurs in Britain, and, indeed, very few inhabit any part of Europe. *S. lineata,* however,—a small species of a deep red colour marked with longitudinal black streaks—is plentiful on umbelliferous plants in the south of France, and along the northern shores of the Mediterranean. The greater proportion of those described in entomological works are from Java, China, East Indies, Cape of Good Hope, and Surinam. Most of these are very splendidly coloured insects, decorated with the deepest tints, and having a fine metallic gloss of golden-green, copper, or silver. The individual figured belongs to Serville's second subdivision that in which there is no abdominal plate; the thorax with a lateral spine; the body long, and narrowing gradually to the hinder extremity. The colour is deep orange yellow, with several black spots, surrounded with light yellow, scattered over the surface but the colour and markings are very variable. It is a native of China and Japan.

PENTATOMA RUTILANS.

PLATE XIX. Fig. 2.

Edessa rutilans, *Fabr.*—Cimex rutilans, *Drury*, Vol. iii. 46, fig. 5.

In the present genus the scutellum is still large, but it covers only a portion of the abdomen. The antennæ have the first or radical joint shortest; the third joint sometimes longest, (as in *Prufipes,*) sometimes shortest, (as in *P. Baccarum,* and *P. Grisea.*) The second and third joints of the rostrum are rather longer than the others; anterior tibiæ notched before the apex; tarsi three-jointed, the middle joint minute. (Pl. XVIII. fig. 9.)

The species of this genus are more widely distributed than their near allies the scutelleræ. Many brilliantly ornamented kinds inhabit the warmer regions of Asia, Africa, and America; no small number are to be found in the continent of Europe; and about fifteen are included in the lists of our indigenous insects.

The beautiful species figured on Pl. XIX. at fig. 2. is a native of Sierra Leone. The thorax is bright nazarine blue, with a scarlet streak across the front; scutellum greenish blue, the tip and margins scarlet; hemelytra blue; abdomen scarlet, with dark blue spots at regular intervals along the sides; underside yellow; legs and rostrum black.

PENTATOMA (*RAPHIGASTER*) INCARNATUS.

PLATE XIX. Fig. 3.

Cimex incarnatus, *Drury* ii. Pl. 36, fig. 5.—Cimex nigripes, *Fabr.—Stoll's cim.* 2, 2 f, 10.

Thorax deep orange red, edged anteriorly with

blue: scutellum the same colour as the thorax, having two blue-black spots anteriorly: tegmina orange red from the base to beyond the middle, with a blue spot in the centre; the extremity olive, with a brassy tint; abdomen orange red, the sides yellowish white with blue marks; underside yellowish white; legs blue. Found in China.

Of the other families belonging to the Heteropterous section, space can only be afforded, in this place for the following examples:—

COREUS (*SYRTOMASTES*) PARADOXUS,

PLATE XX. Fig. 1.

Cimex paradoxus, *Fabr. &c.*

THE genus Coreus is distinguished by having the body oval, the last joint of the antennæ (which consist of four articulations,) ovoid or fusiform, commonly shorter than the preceding. The subgenus Syrtomastes has the last joint of the antennæ a good deal shorter than the preceding one, and nearly oval, while the latter is filiform and simple. Of this group *S. marginatus* is the best known species; *S. paradoxus* is very similar to it, being of a grey colour, tinted in certain places with reddish brown; the sides are fringed with ciliated membranous lobes, which give the insect a very singular appearance. It was first found by Sparmann at the Cape of Good Hope.

CERBUS FLAVEOLUS.

PLATE XX. Fig. 2.

Cimex flaveolus, *Drury* iii. pl. 43, fig. 3.

THIS is another member of the family Coreidæ which

1 Sydamnastes purpdorus 2 Cerbus flavcolus 3 Anisosceles hymeniphem

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according to Mr. Westwood, may possibly be referrible to the genus Cerbus. It is a native of Sierra Leone, about an inch in length, and the greater part of the surface brown; the thorax margined with yellow, and the coriaceous portion of the hemelytra bordered behind and along the apex with a band of the same colour; head and abdomen red; legs yellowish brown, the colour deepening towards the foot.

ANISOSCELES HYMENIPHERA.

PLATE XX. Fig. 3.

FOR a figure and the following notice of this new species of Anisosceles, we are indebted to Mr. Westwood, in whose cabinet the specimen is preserved. The genus must now be restricted to such kinds as have long and slender legs, and the posterior tibiæ furnished with a broad membranous appendage on each side. The type is the common Brazilian Lygæus bilineatus, Fabr (Diactor elegans, Perty; Anisos. latifolia, Serville.) Another species is the A. lacipes, (Guerin's Mag. Zool. pl. 75,) from Mexico. A third species, undescribed, closely allied to the latter, but smaller, with the thorax and hemelytra entirely fulvous red, and the legs entirely pale ochreous, is contained in the collection of the Jardin des Plantes, and to which the specific name of *affinis* may be applied. The species here figured is a native of Mexico; it is about nine lines long, fulvo-testaceous, the thorax with a black line behind, but the margin itself yellow; scutellum black, the edges and central line yellow legs yellow, with black lines,

the membranous expansion of the hinder tibiæ luteous, variegated with testaceous, and marked with a group of small black spots near the middle of the exterior portion.

Homoptera.

This, the second great division of the Hemipterous order, will be readily distinguished by having the rostrum apparently originating from the lower part of the head, near the breast; the hemelytra of a uniform consistence, approaching to membranous, throughout their whole extent; never overlapping each other when closed, and inclined on each side, forming a kind of roof over the body; the latter thick and convex; mesothorax and metathorax more developed than the prothorax; antennæ short and inconspicuous, terminating in a bristle; scutellum minute; ovipositor always distinct.

The above characters sufficiently indicate that this section is widely dissimilar from the former. The differences are not confined to external and structural attributes, but also extend to modes of life, the Homoptera living exclusively on vegetable juices, while the Heteroptera are more partial to the blood of animals. It contains several well defined families, of which we shall first attend to that of the Cicadidæ or frog-hoppers.

Fam. Cicadidæ.

In these the antennæ are very short and setaceous, composed of from three to seven joints, scarcely projecting beyond the head, (Pl. XVIII. fig. 2, *c*, *c*,) the

1 Polyneura ducalis

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latter broad and transverse, never produced in front, with three ocelli on the crown, (Pl. XVIII. fig. 2, *b*,) the hind legs are thickened and adapted for leaping, and all the tarsi are three-jointed; females with an ovipositor; males musical.

The first example of this fine genus, figured for the first time, is named

CICADA (*POLYNEURA*) DUCALIS.

Plate XVIII. Fig. 1.

The head is black, with two minute buff-coloured spots over the insertion of the antennæ. The thorax is considerably broader than the head, and angulated on each side, near the middle, the colour black, with a narrow anterior and broad posterior margin of yellow. The remainder of the body is black, except the posterior margin of the basal segments of the abdomen, which are chestnut in the centre. The legs are black, with the thighs, except at the tip, scarlet. The general colour of the anterior wings is chocolate brown, darkest at the base, the anterior costa at the base, and the veins, of a rich golden yellow; the latter are divided, rather before the centre of the wing, by a curved transverse vein, thicker than the rest; from the base of the wing to this vein, the longitudinal veins are furcate, beyond it they are numerous, and form a great number of irregular shaped cells, (differing on the opposite wing,) and terminating in about twenty longitudinal veins, received by another vein which runs parallel with the exterior margin of the wing. The hinder wings are of a dull buff-ochre colour, paler next the body.

This beautiful Cicada (which Mr. Westwood, to whom we have been indebted for a drawing, considers as forming a distinct subgenus, in consequence of the numerous veins with which the anterior wings are furnished) formed part of the late General Hardwicke's collection made in Nepaul, and presented to the Linnean Society of London. It does not seem to exist in any other collection, either in this country or on the Continent. It is allied to C. fasciata, Fabr. C. speciosa, Illiger, &c., but differs considerably from these and every other described species.

CICADA PLEBEIA.

PLATE XXI. Fig. 1.

Roesel's Ins. Pl. 25, 26.—*Stoll's Cig.* Pl. 24. fig. 131. Pl. 25. fig. 139.

THIS is the largest of the European Cicadæ, being frequently found to measure two inches in length, and 4½ inches between the tips of the wings. The general colour is black, with a yellow line on each side of the thorax, and various smaller stripes of the same colour on different parts of the surface. Underside testaceous-yellow; tegmina and wings transparent. The sound it produces is very loud and shrill. It is first met with on going southwards, in the central provinces of France, and is not unfrequent in many of the southern parts of Europe.

CICADA SEPTENDECIM.

PLATE XXI. Fig. 2. FEM.

Cicad. Manif. Septendecim, *Linn.*—*Stoll's Cicad.* Pl. 3. fig. 14. Kalm Reize door Noord-Amerika.

HEAD black; eyes yellow; thorax and upper parts

1. Cicada plebeia. France.
2. ——— *septendecim.* N. America.

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of the body black; the metathorax edged with yellow; breast and legs deep yellow, more or less spotted with black; abdomen black beneath, each segment with a band of brownish yellow; the hemelytra are transparent, slightly tinged with yellow; the costa and nervures deep yellow; under wings unspotted, deep yellow at the base, the nervures likewise of that colour. Nymph of a uniform brown, the legs reddish yellow.

This insect is a native of North America, and has obtained the name Septendecim from being supposed to make its appearance in large numbers every seventeenth year. This statement was first made by Kalm, and more recent travellers admit that appearances give some countenance to the notion. An interesting account of it will be found in C. J. Latrobe's *Rambler in South America.*

FULGORA LATERNARIA.

PLATE XXII. Fig. 1.

Fulgora Laternaria, *Linn.*—*Roesel* ii. Locust xxviii.—*Merian's Surinam Ins.* Pl. 49. *Stoll's Cicad.* Pl. 1. fig. 1.

THIS genus is, in several respects, one of the most remarkable belonging to the present order. It was first established by Linnæus, under the name Laternaria, an appellation which he subsequently changed to Fulgora. Both these terms were suggested by the supposed luminous properties of many of the species, which, at that time, seemed to be admitted on the most satisfactory evidence. As originally constituted, the genus comprehended many kinds

which are now properly excluded, as their forms and structure were too diversified to be compatible with the notion now formed of a generic group. The Fulgoræ, strictly so called, are such as present the following characters.

The antennæ have the second joint of a globular shape, and covered with pretty large granulations, the terminal seta inserted in the centre of a minute globose joint; ocelli two, placed a little before and under the eyes, between them and the antennæ; forehead more or less produced anteriorly; labrum terminating in an acute point; sucker composed of three joints, its extremity extending at least as far as the insertion of the posterior legs; hemelytra not so broad as the wings, the length greatly exceeding the breadth; legs elongated, adapted for leaping, the hinder thighs strongly spined; prothorax not so broad as the metathorax, and somewhat emarginate on its hinder margin.

Even in the acceptation to which the above definition restricts it, the genus comprehend a considerable amount of species. The greater number of them are insects of large size, and warm if not brilliant colours. The prolongation of the forehead, and the extraordinary forms it assumes, confers on them a peculiar aspect, at once distinguishing them from all other hemipterous tribes.

The larger kinds have long been said to be luminous, and this belief has been so general, that they have obtained the name of fire-flies, mouches à feu, and lantern-flies. But recent travellers agree in

affirming that they never witnessed this phenomenon in any other insects except certain species of Lampyris and Elater. Certain writers of older date, however, affirm that they have, and it is difficult to determine the fact amidst such conflicting evidence. Still, however, when we consider Madam Merian's circumstantial statement, and how improbable it is, notwithstanding the grave errors into which she occasionally falls, that she could be mistaken in a matter so obvious, while, at the same time, she could have no motive intentionally to mislead—that the natives affirm they have sometimes seen it luminous—and that the names given to the insect, both by the colonists and natives, such as Lantarendrager, Porte-Lanterne, mouche à feu, all bear allusion to this property—it may be concluded, that the opinion generally received is nearest the truth. It should be kept in mind that all the negative evidence merely proves that the light is seldom exhibited, while the testimony of a single trustworthy observer affirming that he has witnessed it, is conclusive. All luminous insects are capricious in displaying their radiance; and, in many instances, it is only under a certain combination of circumstances that they can do it at all. In the present case, it may be that only one of the sexes is luminous, and even in the sex so endowed, the property may depend on the age of the individual, the season of the year, and even the state of the atmosphere.

The narrow-snouted Fulgoræ have likewise obtained credit for being luminous, but there is a stil.

greater want of evidence to support this opinion than in the preceding case. They differ so much in the form of the snout, and other circumstances, from the species just alluded to, that we are scarcely entitled to infer that what exists in the one is common also to the others. The Chinese *F. candelaria* is very abundant, and if it be really luminous, the phenomenon must have been often witnessed by European residents; yet all their accounts seem to refer to phosphorescent Lampyridæ and Elateridæ. It is to be wished that some competent observer would undertake to examine the matter, which, to those visiting the countries where the insects abound, will probably not be attended with much difficulty.*

The species referred to above as forming one of the figures on the adjoining plate, is a native of the New World, and found in tolerable plenty in Cayenne, Surinam, &c. The Indians call it *Jacarenam boya*, or the crocodile snake, and seem to suppose that it is venomous, and capable of inflicting wounds. It can fly swiftly, as might be inferred from the amplitude of its wings, and is most active in the twilight and evening. It is extremely well figured by Madam Merian, in her Insects of Surinam; and specimens are to be found in almost every cabinet of any extent in this country and on the Continent.

* In the 3d Vol. of Entom. Magazine, the reader will find collected all that is worth knowing on the luminosity of the Fulgoræ,—and something more.

1. *Fulgora candelaria*. China.
2. ——— *maculata*. Coast of Coromandel.

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FULGORA CASTRESII.

PLATE XXII. Fig. 2.

Guerin's Mag. de Zool. Pl. 173 *et* 174.

THIS insect has been recently made known by the French periodical above referred to; even though it may be thought by some not to be a distinct species, it must be admitted to be an interesting variety. Its chief distinctions from *F. laternaria* are, that the head is narrower than the thorax, and more than twice longer than broad; the hemelytra yellowish-green, variegated with black over the whole surface.

This magnificent insect is a native of Mexico, and still rare in collections. The specific name has been given in honour of Colonel Castres, an enlightened patron of works on natural history. M. Guerin mentions that he has seen another species of Fulgora in the collections of the French Museum, very closely allied to the preceding, but having the snout still more narrow and elongated than in F. Castresii.

FULGORA CANDELARIA.

PLATE XXIII. Fig. 1.

F. candelaria, *Linn. Fabr.—Stoll's Cicad.* Pl. 10, fig. 46; and *A. Roesel's Ins. Locusta*, Pl. 30.

THIS finely coloured species has been long known, and few collections of insects arrive in this country from China without containing specimens. It is usually, in this country, called the lantern-fly. Its appearance and markings are so well expressed in the figure, that we must not occupy space with description.

FULGORA MACULATA.

PLATE XXIII. Fig. 2.

Stoll's Cicad. Pl. 98; Pl. 26. fig. 143, and fig. A.

THIS handsome species is nearly of the same size as that last noticed, and very similar to it in shape. The snout, however, is rather longer in proportion to the body, rather tapering more towards the extremity, and considerably more curved. The whole body, as well as the snout, is black, somewhat shining, and slightly glossed with green; antennæ and eyes greyish; legs brownish-black. The ground colour of the hemelytra is dark-brown, the surface marked with numerous large rounded spots, those towards the base glaucous-green, the others appearing yellowish-green, owing to the numerous reticulated nervures of that colour which traverse them. The wings are brownish-black posteriorly, the whole basal region brilliant bluish-green, which colour emits irregular rays towards the hinder margin.

Found at Tranquebar, on the Coromandel coast.

APHANA SUBMACULATA.

PLATE XXIV. Fig. 1.

APHANA comprehends a number of insects nearly allied to the Fulgoræ, and with which they were formerly confounded. The present species is figured for the first time from a specimen in the Rev. F. W. Hope's collection. The expansion of the wings is not much short of three inches: head, pro- and mesothorax luteous, the former with a short conical flat horn; eyes red; metathorax and abdomen brown; anterior wings rich fulvous-red, a slender apical mar-

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? otus globularis Surinam.
furcatus. Brazil.

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gin of black, and many irregular transverse patches of a paler colour; posterior wings sooty-brown at the base; yellowish-brown at the extremity, with about fifteen larger and rounded spots of white, formed by a cottonny matter. From Assam.

MEMBRACIS FOLIATA.

PLATE XXIV. Fig. 2.

THIS insect affords a good example of a very remarkable genus, distinguished by having the prothorax excessively elevated, compressed, and foliaceous, extending along the back like a kind of roof, under which the body of the insect is almost concealed. It is a native of Cayenne; about four and a half lines in length (the figure being greatly magnified); the colour blackish-brown, the gibbous thorax with a broad arch, and band of white. The hemelytra are oval and much longer than the wings; the legs long, flattened, and rather broad.

PLATE XXV.

THIS plate is devoted to the representation of three species of the singular group named CENTROTUS, which approaches in essential characters to the preceding. Like it the prothorax is large and gibbous, produced in various fantastic forms over the scutellum, which is bidentate at the apex. "Of all Nature's works," says Mr. Curtis, who has illustrated the genus by dissections of a British species,* "amongst the insect tribes, this family is the most remarkable for the grotesque and extraordinary forms the species exhibit: the thorax being produced in the shape of horns of

* Brit. Entom. pl. 213.

the most whimsical figures in various directions; sometimes projecting over the head like a helmet, at others forming a tail, which looks quite artificial, and again assuming the character of ears or the horns of animals."

Fig. 1. *C. globularis* bears a cylindrical horn on the anterior part of the thorax, divided into four branches, each of which terminates in a hairy ball; head black; abdomen fulvous; feet yellow. Length about three and a half lines. Fig. 2. *C. furcatus*, a larger species five lines in length; the prothoracic expansion turned backwards, and projecting from the body, the apex bifurcated; it is a native of Brazil, the former of Surinam and some other parts of America. Fig 3 represents a new and singularly monstrous species from Mr. Hope's collection, who obtained it from that of the late Rev. L. Guilding. Mr. Westwood names it *C. biclavatus*. The colour is obscure brown; prothorax very large, the frontal part elevated into a long thick punctate and setose horn, the tip of which is dilated into a rounded knob; the middle part also elevated into a similar horn, but shorter; tegmina brown; at the posterior angle there is a pale spot, as well as in the middle of the posterior margin. Length three lines; expansion of wings six. A native of South America.

Latreille includes among the homopterous hemiptera the GALLINSECTA, comprising the family *coccidæ;* also the APHIDÆ, containing *Psylla, Aphis,* and *Thrips*. Mr. Haliday has recently formed the latter into a separate order, which he names *Thysanoptera*.

Order IV.—Neuroptera.

As has been seen by the brief synoptical view given on a former page, this order is essentially characterised by a mouth organised for gnawing, and four naked membranous wings of equal consistency—that is, the superior pair are not thickened for the purpose of protecting the others, as is the case with the orders hitherto described. To these must be added, in order to render the definition exclusive of some of the following orders, that the wings are reticulated or interlaced with a delicate net-work—a character indicated by the name, which is derived from *νευρον*, a nerve, with the ordinary postfix.

All the wings are fully fitted for flight, and in the majority of cases both pairs are of equal size, as we see them in dragon-flies. But in some tribes the posterior pair are smaller than the others, (in this respect resembling the Hymenoptera,) and in a few cases they entirely disappear.* The reticulations are finer and denser in some than in others, but they are always too numerous, variable, and minute to be available for the purposes of classification, like the cells of the Hymenoptera. When at rest their position is various, but most commonly they are extended at right angles from the body, nearly in the same manner as they are borne during flight. In other cases, the upper pair are incumbent on the lower, and deflexed at the sides. It might at once be inferred

* In Neuroptera the hinder wings assume a remarkable form, being long and linear, extending behind the insect like two tails.

from examining the wing of a dragon-fly, that this is one of the orders in which flight attains its maximum of power. The insect just named has always been celebrated for its easy and rapid evolutions, and like a few other kinds, it is able to dart backwards or sidewise with equal ease.

The head is frequently of large size, and in the species most strongly characteristic of the order, the greater portion of it is occupied by the composite eyes, which are unusually developed in harmony with their predacious habits. The ocelli, when present, (which is commonly the case,) are placed on the forehead, and are often very conspicuous. Such, however, is not generally the case with the antennæ, as they are short, subulate, and slender, in one principal division of the order; but in the other, they are longer and occasionally very prominent.

The trophi are strictly of a masticating kind, and in not a few instances, exactly like those of the Orthoptera. Their appearance in Libellula is accurately exhibited on Pl. XXVI.

Figures 1–10 comprise details of the head of the common dragon-fly, *Libellula depressa* (fem.) The first five figures represent the head in different positions; the same letters are, throughout, applied to the same parts.—Figure 1, the head seen from above, fig. 2, from beneath, fig. 3. in front, fig. 4, from behind, fig. 5, laterally; *p*, the vertex, and *q*, *q*, the occiput, reduced to a minute size by the enlarged size of the eyes, *e*, *e*; *o*, the ocelli; *a*, *a*, the antennæ; *b*, a tubercle enclosed between the eyes and ocelli; *c* and *c'*, the face, divided into two parts, (the nasus and postnasus of Kirby, Intr. Pl. 6, p. 10, *a*, *b*;) *d*, the clypeus, (Rhenarium,

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Kirby, loc. cit. *f* 10, *g'*;) *f*, the upper lip, (labrum;) 7 *a*, the external lobe, and 7 *a b*, the internal lobe of the maxillæ; a^x, the membranous base of the lower lip; *g a*, the lower lip; *g b*, the basal joint, and *g c c*, the outer joint of the labial palpi, (outer lobes of the labrium, K. and S.)

Fig. 6, one of the mandibles. Fig. 7, one of the maxillæ, destitute of maxillary palpi; *a*, the external lobe or galea; *b*, the internal lobe; *c*, the stipes or stalk; *d*, the cardo or hinge. Fig. 8, the internal tongue (lingua.) Fig. 9, the lower lip; *g a*, the labium; *b b*, the basal, and *c c*, the terminal joint of the plate-like labial palpi, according to Latreille, or the lateral lobes of the labium, according to Kirby. (Intr. Pl. 6, *f*, 12, *b'*.) Fig. 10, one of the antennæ (7 jointed.)

Figs. 11–13 represent the front of the body of the larva of the same insect, to shew the construction of the mask of the face and its analogous structure to the lower lip of the imago. The parts are lettered as in the preceding figures. Fig. 11, the head, with the mask at rest and closed upon the face; 4 a^x, the basal portion or fulcrum (K.) by which the mask is attached to the head; *g a*, the lip; *g c*, the lobes. Fig. 12, the head, with the mask in action, opened to seize the prey; lettered as above. Fig. 13, the mask seen from below and expanded. Fig. 14, the antennæ (7 jointed,) of the larva.

The abdomen of most Neuropterous insects is of great length, compared with the other primary segments of the body. It is remarkably long and slender in the genus Agrion, particularly in the South African species and its allies, (*A. Linearis*, Fabr. *Leste Lucretia*, Leach.) That of the male commonly terminates in two or three prehensory appendages; sometimes, in both sexes, in two or three long slender tails or filaments; and in Panorpa it ends in an articulated tube terminating in a hook. The legs,

in most cases, are short and slender, the tarsi varying in the number of joints from three (their amount in dragon flies,) to five (as among the Hemerobii, &c.)

The transformations of this order differ in their nature in different tribes, some undergoing a semi-metamorphosis, others a complete one. The larvæ are constantly provided with six feet, and many of them reside in the water. The majority of the larvæ, as well as of the perfect insects, are carnivorous; a few are omnivorous in all their states.

We have upwards of 200 Neuropterous species in Britain, and of these certain of the Libellulæ are among the largest insects found in this country.

Latreille divides this order into two primary groups, discriminated by the shape of the antennæ:—SABULICORNES, having these organs minute and setiform, with not more than seven joints; FILICORNES, having long antennæ, composed of numerous joints, and for the most part filiform. The former section comprehends the families Libellulidæ (*Dragon-flies,*) and Ephemeridæ (*May-flies;*) the latter contains the Panorpidæ, (*Scorpion-flies,*) Myrmeleonidæ, (*Ant-lions,*) Hemerobiidæ, (*Day-flies,*) Termitidæ, (*White-ants,*) Raphidiidæ, Psocidæ, Perlidæ.

The dragon-flies are well known insects, owing to their large size, frequent occurrence, and their beautiful and varied colouring. Such of them as are now referred to the old genus Libellula, may be recognised by having their wings extended horizontally during repose; a vesicular elevation on the

1. *Libellula quadrimaculata*. Britain
2. ——— *Portia*. Sierra Leone
3. *Nemoptera angulata*. Cape

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vertex, with an ocellus on each side of it, and another of larger size in front; the central lobe of the labium much smaller than the lateral ones; abdomen as broad as the thorax, or nearly so. Larva and nymph aquatic, the body short and rather thick, with five appendages at the hinder extremity; respiration through the tail.

LIBELLULA QUADRIMACULATA.

PLATE XXVII. Fig. 1.

Linn. Donovan's Brit. Ins. XI. Pl. 407. *Samouelle's Compendium*, Pl. 7, fig. 1.

WE give this as a British example of the genus; besides it, about eight others are found in this country. It is not one of the largest size, its dimensions scarcely equalling those of the more common L. depressa. The general colour is reddish brown, the wings transparent, and each of them with a large brown patch at the base, and another of smaller size beyond the middle. This species was long regarded as rare, but since the investigation of our indigenous insects came to be more attended to, it has been found not unfrequently in nearly all parts of the country. In the neighbourhood of Edinburgh it occurs at Duddingston Loch, among the Pentland Hills, and elsewhere.

LIBELLULA PORTIA.

PLATE XXVII. Fig. 2.

Drury's Ex. Ins. II. Pl. 47, fig. 3. L. Marginata, *Fabr. Ent. Syst.*

THIS small and finely coloured species is a native of

Sierra Leone. The thorax and abdomen are entirely bright blue; head black; wings dark brown anteriorly, the hinder part clear and transparent.

LIBELLULA AXILENA.

PLATE XXIX. Fig. 1.

West. Drury, Pl. 47, Fig. 1. Lib. Lydia, *Drury*, App. Vol. II.

As specimens of exotic dragon-flies, we introduce this handsome species, and another scarcely inferior to it in the beauty of its colours. The head is marked with five white spots; the thorax brown above, with a slight golden tinge, and the sides pale green; abdomen black along the back, the sides dull orange, the underside and base pale green. The wings have an interrupted black border anteriorly before the middle, and a black streak at the base; the tips brownish. This insect is a native of Virginia.

LIBELLULA PULCHELLA.

PLATE XXIX. Fig. 2.

Lib. bifasciata, *Fabr.* Lib. Pulchella, *Drury*, Pl. 48, fig. 5.

Forehead green; eyes brown, with two yellow spots behind each; thorax brownish green, with two yellow streaks on each side; abdomen blue in the male, with yellow marks at the sides of some of the segments, wholly yellow in the female. Wings with three brown clouds on each, one at the base, another in the centre anteriorly, the third covering the apex, and having a black streak above it on the margin; between these clouds the male has a white patch on each wing, and another on the abdominal edge of

1 Libellula arilena. 2 Libellula nuichella.

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Lizars sc

1. *Æshna grandis.* Britain.
2. *Stilbopteryx costalis.* Australia

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the posterior ones; legs black. A native of the country round New York.

ÆSHNA GRANDIS.

PLATE XXVIII. Fig. 1.

Lib. Grandis, *Linn. Fabr. Donovan's Brit. Ins.* X. 30, Pl. 337, fig. 2. *Harris Expos.* Pl. 12, figs. 1, 2. *Roesel Insects*, IV.

THIS genus includes the largest four native dragon-flies. The horizontal position of the wings, when at rest, distinguishes it from *Agrion*, to which it is in many respects very closely related, and the long narrow abdomen, which never approaches to the diameter of the thorax, is the most obvious distinction from Libellula. The two posterior ocelli are placed on a transverse ridge, and the central lobe of the labium is rather large, while the two lateral ones are divergent, armed with a strong tooth, and having a spinous appendage attached to them. The larva and nymph are more elongated than in Libellula, and the structure of the mask is somewhat different. About half a dozen species occur in Britain. *Æ. grandis* is two inches and a half in length, of a fulvous brown colour, with two yellow stripes on each side of the thorax, the abdomen variegated with green or yellow. It is of occasional occurrence on moors, marshes, &c. throughout the country.

NEMOPTERA ANGULATA, *West.*

PLATE XXVII. Fig. 3.

Westwood; Trans. Ent. Soc. Vol. 1, p. 75.

OF the family Panorpidæ, which contains but few

genera, we present as an example a new species of Nemoptera, a group of very remarkable aspect, owing to the extraordinary elongation and narrowness of the posterior wings. The specific name refers to the shape of the anterior wings, which are more acutely angular at the tips than in any other known species. It is closely allied to *N. Africana* of Leach, but differs in the form of the wings, black stigma, spotted anterior margin of the fore wings, and brown base of the posterior pair. It is figured of the natural size. It is from the Cape of Good Hope.

STILBOPTERYX COSTALIS.

PLATE XXVIII. Fig. 2.

Newman; Ent. Mag. No. 24, p. 400.

THIS insect was first described by Mr. Newman in the work mentioned above, to which we must refer for a detailed account. It belongs to the family Myrmeleonidæ, and differs from the typical genus Myrmeleon chiefly in the very short palpi, (the maxillary pair having only four joints,) and in the neuration of the posterior wings, the fourth longitudinal nerve not being furcate, and the fifth extending considerably beyond the same nerve in the anterior wings, as though it had united with the lower fork of the fourth nerve, and thus supplied its place.

The insect is a native of Australia; the specimen figured is in the Rev. Mr. Hope's collection.

ORDER V.—TRICHOPTERA.

THIS order, which is not adopted by all entomolo-

gists, was established by Kirby for the reception of the Linnean genus *Phryganea*, previously associated with the Neuroptera, but to which its characters by no means conform. Instead of being reticulated, the neuration of the wings is simply branching, the nervures disposed in a manner bearing some resemblance to that observed among the Lepidoptera. The upper pair are mostly hairy, (hence the name from θριξ, τριχος, hair,) the under pair ample and folded. The organs of the mouth are in a great measure obsolete, the mandibles being either entirely wanting or very imperfect. Such is likewise the case with the maxillæ and labium, but the palpi are developed. The abdomen is never furnished with terminal setæ, and the tibiæ of many are armed with two pair of spurs, as in many kinds of moths.

The larvæ are aquatic, and construct a kind of case to reside in, from which circumstance they are often called *case-worms*. These cases are formed of various materials, and often present a singular appearance by being stuck over with small shells, pebbles, &c. The pupa is incomplete, and is enclosed in the case constructed by the larva, a grating being formed at the end, apparently for the purpose of facilitating respiration. The perfect insects are usually termed *caddice-flies*, and are frequently used, as well as the larvæ, by anglers as a bait for fish. They fly heavily, and commonly settle on bushes near the water's edge. Most of them are of a brown colour, with little variety of markings. Probably

about 200 different species inhabit this country. As an example of this order we have figured

PHRYGANEA GRANDIS.

PLATE XXX. Fig. 1.

Linn. *De Geer*, II. 388, Pl. 13, fig. 1. *Kirby and Spence's Introd.* III. 68, Pl. 3, fig. 4.

THE upper wings are brownish grey, with cinereous spots, a longitudinal black ray and two or three white points at the extremity; antennæ as long as the body. Found plentifully in many parts of the Continent, and not unfrequently in Britain.

ORDER VI.—HYMENOPTERA.

THE name of this order being derived from *υμην*, a membrane, is not distinctive, the wings of several other orders being likewise membranous. They are four in number, and of a uniform texture throughout, the upper pair being always larger than the under pair. They are permeated by a considerable number of nervures, which usually radiate from the base, and form areas of greater or less extent over the surface, but these are never so small and numerous as to resemble the reticulated wings of the Neuroptera. The mouth essentially consists of mandibles, maxillæ, an under and upper lip, and palpi. The females are provided with an ovipositor,—sometimes resembling a pair of saws, and at other times assuming that modification of form in which it is named a sting, —and the tarsi are in most cases pentamerous.

These general properties may suffice to separate

ypanea grandis. 2 Cimbex 10-maculata. 3 Athalia centifoliae. 4 Caterpillar of Dº

Britain. Britain. Britain. Britain.

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the Hymenoptera from the rest of their class, but it is necessary to describe the various parts more in detail.

The head is not received into a cavity of the thorax, but is attached to it by a ligament, so flexible that the head can be almost turned round upon it. It is likewise capable of some extension, and the head has thereby considerable freedom of motion. The composite eyes are sometimes larger in the males than in the other sex. The stemmata are always three in number, commonly disposed in an equilateral triangle, but occasionally almost in a transverse line. In the organs of the mouth we can distinctly recognise mandibles, maxillæ, lingua, labrum, labium, and palpi; but these parts are so variously modified in different tribes, that a general definition of them will possess little value. The mandibles are strong and salient, usually toothed, and sometimes each blade appears as if formed by the union of two similar pieces. The maxillæ are usually much developed, the blade or stipes often greatly elongated, and the insertion (the cardo or hinge of Kirby,) distinctly visible. The blade of the maxillæ acts an important part in composing the tube in honey-sucking tribes. There are commonly two lobes at the extremity, which are sometimes acute, at other times very obtuse. The palpi attached to this blade are almost always long, and in the greater number of instances contain six joints; in the minute parasites, however, they are frequently abnormal, and often present only two articulations. The labium is much larger than

in most of the other orders, and all the accessory parts are strongly developed.

These, and other parts of the oral appendages, are represented on Pl. XXVI.

Figs. 15 and 16, the maxilla and labium of a Tenthredo.—Fig. 15, the maxilla;—*l i*, the inner lobe, and *l e*, the exterior lobe representing the galea; *c*, the stipes; *d*, the cardo; *p*, the palpus (six-jointed.)—Fig. 16, the labium;—*m n*, the mentum; *l* 2, the trilobed labium; *l p*, the labial palpus.

Fig. 17, the maxillæ and labrum of *Sirex juvencus* (male;) *m x*, maxillæ; *m x p*, maxillary palpi; *a*, the fulcrum; *m n*, the mentum; *l* 2, the lower lip; *l p*, the labial palpi.

Figs. 18–23, oral organs of a *Pimpla*.—Fig. 18, the head seen from the front;—*a*, antenna; *e e*, the eyes; *o*, ocelli; *l i*, the minute upper lip; *m*, the mandibles; *m x p*, maxillary palpi; *l p*, labial palpi.—Fig. 19, head seen from behind;—*m n*, the mentum; *l* 2, the labium; *m x*, the maxillæ; *m x p*, the maxillary palpi; *l p*, labial palpi.—Fig. 20, labrum;—*l* 1, the appendiculata (Kirby and Spence.)—Fig. 21, one of the bifid mandibles.—Fig. 22, maxilla;—*l e*, external lobe; *l i*, internal lobe; *c*, stipes; *d*, cardo; *p*, maxillary palpus.—Fig. 23, lower lip;—*a*, fulcrum; *m n*, mentum; *l* 2, labium; *l p*, labial palpi.

The variations of the antennæ are too numerous to be specified in this place. The number of joints is from three (their amount in *Hylotoma*) to about fifty. These multiarticulate antennæ are chiefly to be found among the Ichneumonidæ, whose economy renders it necessary that they should be very flexible for the purpose of exploring the holes and crevices into which they introduce their eggs. In some instances the antennæ are bipectinated; in other cases (as in *Cryptus*) they appear double, the third joint being long and furcate. They are often very dissimilar in

the two sexes. In the genus just named, for example, the male antennæ are quite simple, and filiform, while the female exhibits the remarkable peculiarity just alluded to.

The prothorax is usually small in hymenopterous insects, but in many cases it is quite distinct, while in the Chalcididæ, Uroceridæ, &c. it forms a considerable portion of the dorsal area. The latter, however, generally consists of the mesothorax, which is here greatly enlarged, in order to afford sufficient momentum to the fore wings, on which the power of flight, in this order, chiefly depends. It is therefore this section of the thorax, which, in descriptive language, is spoken of simply as the thorax. The metathorax is proportionably diminished, but still holds sufficient prominence to correspond with the importance of the hinder wings, which are also essential to flight; and it seems to become enlarged as the size of the hinder wings increases.

The structure of the wings, and the arrangement of the nervures, have been perhaps more carefully studied in this than in any of the other orders, partly in consequence of their having been made the basis of a systematic classification of the genera. Taken in connection with characters derived from other parts, they must be admitted to afford valuable marks of distinction, both among the Hymenoptera and Diptera. It is, therefore, important, that the designations of the nervures and the cells formed by their intersection should be explained. When the nervures of the upper wings exist in their maxi-

mum state of development, they are five in number. The longitudinal one placed along the anterior border of the wing, is usually called the costal nervure: it was named by Jurine, who first gave a nomenclature to these parts, the radius, from a notion that it was analogous to the bone so named in vertebrate animals. For the most part this is the strongest nervure in the wing, as it forms the anterior edge when that organ is extended, and has, therefore, to cut through the air during flight. The nervure next to this, and running parallel with it, is the sub-costal nervure,—the cubitus of Jurine. Both these terminate in an opaque expansion on the anterior border of the wing not far from the middle, which is called the stigma, a term which has been appropriated to a totally different part of structure, but is now in too general use in its twofold sense to be disturbed. The sub-costal gives off, a little before its origin, a third nervure, which runs almost in a direct line towards the centre of the wing, and, at a longer or shorter distance from its commencement, describes numerous zigzag lines; this it has been proposed to call the medial nervure. Beyond this a pretty wide area usually intervenes, which is bounded posteriorly by a nervure running somewhat obliquely towards the centre of the hinder border, which has received the name of sub-medial. The last is more slender than the rest, and has been very appropriately called the anal nervure.

The nervures just described are always more or less united by transverse and recurrent nervures,

enclosing small cells which derive their names from the adjacent nervures. Thus the space or cell, situate between the costal and sub-costal nervures, is called the costal cell; that bounded by the sub-costal and medial nervures, the medial cell; and so on.

On attending to the smaller nervures which usually occupy the exterior half of the wing, we will perceive one taking its origin from the stigma or from the extremity of the sub-costal nervure, and running towards the apex of the wing. This is named the radial, and the space between it and the anterior margin. the radial cell. The latter is commonly divided into two by a secondary nervure, in which case there are said to be two radial cells. The exterior of these is said to be appendaged, when the recurrent nervure springs not from the stigma but from the external margin of the wing.

A second nervure, named the cubital, springing from the extremity of the sub-costal nervure, or the recurrent branch which unites the latter to the medial, is directed like the former to the extremity of the wing, which it usually reaches a little below the apex. The enclosed space is divided by cross nervures into cells, which are named cubital cells.

Between the nervure so named and the sub-medial, a considerable space likewise exists, which is also divided by intersecting nervures. The cells thus formed Latreille has proposed to call discoidal. Two cells may be observed in the space

comprised between the sub-medial nervure and the posterior margin of the wing, which are denominated the posterior cells.

"Such is," says Lacordaire, of whose accurate summary we have occasionally availed ourselves in the preceding description; "such is, with a few modifications relating rather to the form and size of the cells than their number, the reticulation of the wings of the Hymenoptera, composing the genera Tenthredo, Cimbex, Allantus, Urocerus, Sirex, &c. On examining the series of genera to the opposite limits of the order, we perceive changes introduced more or less important in proportion as we recede from the groups just named. Even among the Evanii, which are very nearly allied to them, we observe only four principal nervures, and the cubital and discoidal cells are each of them reduced to one. In almost all the genera which follow, the nervures, instead of extending to the edge of the wings, terminate in the middle of the surface. If the cells are closed they retain their usual form; but if, as often happens, they are not united by transverse nervures, they remain open, and are then said to be incomplete. It likewise happens occasionally, that a cell at its base does not occupy the same space as that which precedes it, and is united to the latter by a kind of stalk more or less elongated; the cell so circumstanced is said to be *petiolated*. Following these degradations we see the cells gradually disappear by turns, till we come to *Psilus*, in which

there is no trace of them, except in the costal alone, which loses itself in a scarcely perceptible stigma."*

The value of the generic characters afforded by the modifications which the figure of the cells undergoes, may be inferred from the fact stated by M. Jurine, that he could, in most cases, determine the genus of a hymenopterous insect from the inspection of the wings alone.

As among the Hemiptera, the inferior wings are more or less closely united to the superior when in action, but this is effected by a different kind of mechanism. Along the anterior edge of the secondary wings is placed a series of very fine hooks, (*hamuli,*) which attach themselves to the hinder margin of the primary pair, and a continuous surface of some extent is thus presented to the air.

From the preceding details it may be inferred that the Hymenoptera possess great powers of flight. It is in fact one of the orders in which that power has reached its maximum; all the necessary conditions being found united. The great distances to which bees fly in search of honey, often against a strong wind, are well known; and even when they are loaded with pollen, or other substances—with "treasures sucked from buds and bells"—the rapidity of their aërial movements appears in no degree retarded.

The humming noise which many of them emit is not produced by any organs specially formed for that purpose, as among the Hemiptera and Orthoptera,

* Intro. à l'Entom. I. 368.

which are the only tribes so endowed. It is occasioned simply by the forcible expulsion of the air from the thoracic spiracles. It was long thought to be caused by the vibration of the wings; at other times it was attributed to the friction of the base of these organs against the hard sides of the thorax. But both these opinions are disproved by the fact, that the sound can be produced in certain cases when the wings are entirely removed. Although it has not its source in these organs, it is obvious, however, that it is materially modified by them. This can easily be proved by cutting off a portion from the extremity of the wings, when the sound will become weaker and more shrill, and it decreases in sensibly as the mutilation is carried downwards to the base. If the portion of the latter inserted into the thorax be completely removed, the sound in general will no longer be produced. The secondary part which the wings thus take in its production, becomes apparent when we reflect on the manner in which respiration is performed among insects. The air is forcibly expressed from the thoracic spiracles only when the muscles of the thorax are in strong action; when the insect is in repose or merely using its legs, these spiracles take scarcely any part in the office of respiration, and, consequently, are incapable of producing sound. No sooner, however, are the wings brought into action than they cause the play of the numerous powerful muscles with which the thorax is filled; their contractions and movements compress the trachea in all directions, and the air

is necessarily forced through the only openings which present themselves. The more rapid the flight, the greater must be the muscular action, and, consequently, the expulsion of the air more violent; conditions which perfectly accord with the various degrees of intensity observed in the sounds emitted in different states of movement. When a portion of the wing is cut off, the rapidity of flight is necessarily diminished, and the muscles contract but feebly, in consequence of the lever which moved them being shortened. If the lever be completely taken away, which cannot be done without the laceration of some of the muscles, the contracting power cannot be exercised with sufficient force to eject the air, or, in other words, produce sound. In accordance with this view, the sound is found to be immediately stopped, if the apertures of the spiracles be filled up with gum or any other adhesive substance, and cannot of course be produced in whatever state the wings may be.

The abdomen in hymenopterous insects is often very small, and in some extensive tribes it is attached to the thorax by a very slender segment forming a kind of foot-stalk. The most remarkable appendage connected with it is the ovipositor, which, in most tribes, is very much developed. This instrument assumes a great variety of forms in different families to adapt it to their diversified economy; and, in all, exhibits a beautiful example of mechanical contrivance.

The members of this interesting order usually

live, in their perfect state, on flowers; some of them subsisting on honey and the juices of fruits, while others are carnivorous. The larvæ are very diversified both in their habits and structure.

These insects are very numerous and widely distributed. In amount of species they are probably next to the Coleoptera and Diptera; and as the societies many of them form are exceedingly populous, the number of individuals must be very great. Considerably above 2000 have been described as British, but as many of the parasitical kinds are very minute, it is likely that no small number remain undetected.

Latreille divides the order into two great sections. I. TEREBRANTIA, in which the females are provided with a saw-like ovipositor. This he divides into two subsections:—1*st*, *Securifera;* having the abdomen sessile and provided with a saw; larvæ with feet. Fam. *Tenthredinidæ, Siricidæ.* 2*d*, *Pupivora;* abdomen pedunculated and provided with a borer; larvæ without feet. Fam. *Evaniidæ, Ichneumonidæ, Cynipidæ, Chalcididæ, Proctotrupidæ, Chrysididæ.* Section II. ACULEATA; abdomen of the females armed with a sting. This includes four subsections. 1*st*, *Heterogyna;* females or neuters wingless. Fam. *Formicidæ, Mutillidæ.* 2*d*, *Fossores;* females winged, wings not folded, basal joint of posterior tarsi simple. Fam. *Sphegidæ, &c. &c.* 3*d*, *Diploptera;* females and neuters winged, wings folded. Fam. *Vespidæ, &c.* 4*th*, *Mellifera;* females and neuters winged, wings not folded, posterior tarsi

with the basal joint much dilated. Fam. *Andrenidæ*, *Apidæ*.

In illustrating this order more in detail, we shall first select a characteristic example from the family of the Tenthredinidæ.*

Fam. Tenthredinidæ.

This extensive family may be known by having the abdomen sessile, or united by its whole breadth to the hinder part of the thorax, in such a manner, that it possesses but little power of separate movement. The maxillary palpi are always six-jointed; the labial four-jointed; labium trifid; wings ample, and provided with many complete cells; females with an ovipositor.

It is from the use and appearance of the instrument just named that these insects are called *saw-flies*. It is placed at the extremity of the abdomen of the female, on the under side, and is so constructed, that it combines the properties of a saw and auger. It consists of two plates of the same form and size as two external valves, which serve as a sheath to them, and enclose a short triangular

* We purposely exclude from these illustrations the most interesting of all the hymenopterous families, the *Apidæ*, as their history is given, in a way commensurate with its importance, in a separate volume. The details there afforded of this characteristic group are so ample, as to preclude the necessity of entering at such length into the generalities of the order in the above sketch, as it would otherwise have been necessary to do.

appendage at their base. The lower edge of each of these plates is finely toothed throughout its whole extent, the teeth directed backwards, and at the same time turned a little outwards. The surface of these plates is very smooth internally, but the outer side is partly covered with very closely placed oblique striæ and elevated lines. When the instrument is put in motion on the surface of a leaf, or on a twig, the small teeth act as a saw, while the lateral ridges perform the office of a file or rasp. By this means a suitable opening is soon formed for receiving the eggs. These are sometimes placed within the woody substance of the branches of shrubs, but more commonly they are attached to the leaves. An instance of the former sort is observed in the Rose Saw-fly, (*Hylotoma Rosæ*,) and a familiar example of the latter in the species which infests gooseberry and currant bushes, which arranges its eggs in rows along the mid rib and principal nervures of the leaves. In all cases the eggs are not long in being hatched; and the young larvæ generally find their appropriate food in the leaves of the plant on which the provident mother had placed them.

From the general resemblance these larvæ bear to the caterpillars of butterflies and moths. they are called *false caterpillars*, as the word caterpillar ought to be restricted to the former. A very slight examination is sufficient to enable one to discover decided marks of distinction between them. The true caterpillars—the larvæ of Lepidoptera—have never

more than sixteen feet, while the larvæ of saw-flies have generally from eighteen to twenty-two; a few have only six, a circumstance which again distinguishes them from true caterpillars, in which the number of these parts is never below ten. Another mark of distinction is afforded by the structure of the feet. In lepidopterous larvæ the abdominal legs are surmounted by a coronet of small hooks, appendages which are never found in those of false caterpillars, as the latter are simply mammiform protuberances. This minute difference, which can only be detected by the microscope, has however a material influence over the habits of the respective caterpillars, which often enables us to distinguish them at first sight. The coronet of hooks converts the membranous or abdominal legs of true caterpillars into efficient instruments of prehension, and they accordingly fix their body by means of them to the plane of position, while the head and anterior part remain free. The abdominal legs of the others, on the contrary, are mere points of support, incapable of clinging to an object, and the larva consequently fixes itself by its pectoral or forelegs, which are much developed for the purpose. The whole of the abdominal portion of the body is thus left at liberty, and it is either borne curved inwards, (as in the gooseberry saw-fly,) or projects into the air in variously contorted and singular postures, as is remarkably exemplified in the willow saw-fly, (*Nematus Capreæ*,) and the larva of Hylotoma Rosæ, which has the extremity of its

body almost always elevated and curved in the form of the letter S. Additional distinctive characters might be mentioned, such as the form of the eyes, which are pretty large in pseudo-caterpillars, and placed one on each side of the head, while in true caterpillars they are small almost invisible points disposed in a circle; but those already referred to will suffice to distinguish the two tribes.

The body of pseudo-caterpillars is generally composed of twelve segments, but the incisures are indistinctly defined, and liable to be confounded with the transverse wrinkles which thickly cover the whole surface. Many of them are marked with bright and varied colours, but the majority are of one colour. In this respect they often undergo a remarkable change after they have cast their last skin, the colour becoming entirely unlike what it was before, so that it is impossible to recognise the same individual. This change, indeed, extends even farther than to colour, for such kinds as are furnished with tubercles or spines in their earlier stage, lose them at their last moult and become smooth; that of the gooseberry species, for example, loses the black tubercles which made the surface appear as if shagreened. Like the flies they produce, these larvæ are sluggish and inactive, seldom moving from the place where they have fixed themselves, unless when requiring an additional supply of food. When not engaged in feeding, or when apprehensive of danger, they roll themselves into a circle, sometimes with the tail elevated in the centre. The greater

number live exposed on the foliage of plants, but others take up their abode in the interior of slender shoots and feed upon the immature pith; others lodge in the interior of fruits and cause them speedily to decay.

The first insect selected as an example of the family of saw-flies, is named

CIMBEX DECEM-MACULATA.

PLATE XXX. Fig. 2.

Leach Zool. Mis. III. p. 106—*Curtis' Brit. Ent.* I. Pl. 41.

THE genus cimbex possesses six-jointed antennæ, of which the second joint is much the longest, and the terminal one oblong and club-shaped. The two terminal joints of the maxillary palpi are small and ovate; the labial palpi scarcely longer than the labium; labrum small and oblong; mandibles large and acute, the inner side irregularly toothed; hinder thighs very thick in the males; the tibiæ terminated by a pair of obtuse spurs, and the tarsal joints produced into a spine beneath.

The larvæ of Cimbex have twenty-two feet; and some of them, when annoyed, are capable of squirting a greenish liquid from two lateral apertures. When about to enter the pupa state, they form an oblong hard case, which is usually attached to the tree or shrub on which they fed. We have seven or eight British species, of which the above is one of the rarest. The body is black, the abdomen tinged with violet, the third and seventh segments

with a greenish-yellow spot on each side, the three intermediate joints of the same colour with violet-black in the centre; antennæ and tarsi testaceous; wings pale fulvous.

ATHALIA CENTIFOLIÆ.

PLATE XXX. Fig. 3. Fig. 4, Caterpillar.

THIS is the Turnip saw-fly, which has occasioned so much loss to agriculturists within the last few years. It is about four lines in length, the figure on Pl. XXX. being considerably magnified in order to show the parts more distinctly. The general colour is bright orange yellow; antennæ and head black, the underside of the former dull yellow; palpi yellow; thorax black, the collar, a triangular spot in front and sometimes one behind, reddish-orange; abdomen and legs reddish-yellow, the tips of all the tarsal joints and of the tibiæ black; wings yellowish at the base, the costa and stigma dark-brown. The caterpillar, (Pl. XXX. fig. 4,) has six pectoral, fourteen abdominal, and two anal feet. It is of a dull slate or greyish-black colour, with a somewhat lighter line along the sides just above the feet. It is known in different parts of the country by the names of *black palmer, black canker, black slug* or *caterpillar, negro* or *nigger*.

Full descriptions and history of this insect, which it is desirable should be well known in order that some remedy may be devised against its depredations, will be found in Mr. Yarrell's paper in the second

1.Sirex gigas. 2 Vermex columba. 3 Ioppa picta

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volume of Transactions of the Zoological Society, Mr. Newport's Essay, Curtis' Brit. Ent. fol. 617, and in the Quarterly Journal of Agriculture.

SIREX GIGAS.

PLATE XXXI. Fig. 1.

S. gigas, *Linn.* fem.; *Donov.* vi. Pl. 197, fem. S. marisca, *Linn.* Male.

THE structure of the oral organs in this genus has been minutely delineated on Pl. XXVI. The group is a very distinct one, and contains about half a dozen of very conspicuous British species. *S. gigas* is rare, but is found occasionally in the more southern counties of England, generally frequenting pine woods. The abdomen of the male is yellow, with the hinder extremity black; the female black, with the second and three last segments of the abdomen yellow.

The larvæ live in trees, to which they sometimes prove very injurious.

TREMEX COLUMBA.

PLATE XXXI. Fig. 2.

Sirex columba, *Linn.* S. Pensylvanicus, *De Geer, Mem.* iii. Pl. 30, fig. 13. *West. Drury*, Pl. 38, fig. 2.

THIS species affords an example of the Siricidæ of the New World, it being a native of the country round New York and other parts of North America. The head and thorax are brown orange; abdomen cylindrical, black, with five broad yellow bands, the hinder one interrupted; apex of the abdomen likewise tipped with yellow; legs orange brown.

JOPPA PICTA.

PLATE XXXI. Fig. 3.

THIS and the species delineated on the following plate, afford examples of the very extensive family of the Ichneumonidæ, whose economy is so remarkable. They deposit their eggs in the bodies of other insects, particularly caterpillars, which are there hatched, and the young feed on the entrails of the unfortunate victim. To enable them to convey their eggs into holes and fissures where caterpillars or pupæ often lurk, they are generally provided with a long ovipositor, which is usually very slender, and too weak to pierce the skin of the hand, although the insects often make the attempt when seized. As this weapon generally appears tripartite, these insects were formerly named *Muscæ tripiles*, and, from their habit of vibrating their antennæ, *Muscæ vibrantes*. They may, in general, be known by their narrow elongated form, attenuated, and, in most cases, petiolated abdomen, with its hair-like appendages behind, and long many-jointed antennæ, which are often recurved and annulated. The Ichneumonidæ are a very numerous tribe, no fewer than 1300 European species having been described by Gravenhorst in his monograph of this family, and of these a large proportion occur in Britain. Our British species, however, have not yet been carefully investigated, and it is much to be desired that some competent observer would undertake the task. These insects perform an essential service by destroying so

1 Pimpla manifestator. 2 Stephanus coronatus. 3 Pelecinus polyturator.

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many caterpillars, which, if left to multiply unchecked, would totally consume many of our most useful plants.

The genus Joppa is principally distinguished by the form of the antennæ, which are much thickened beyond the middle, and then terminate in a point, as is well seen in the handsome species (*J. Joppa,*) figured on Pl. XXXI.

Another example of this genus is given on Pl. XXVI. fig. 24, *J. antennata,* (Fabr. Syst. Piez. 122, Ent. Syst. 158, Ichneumonia,) from a drawing by Mr. Westwood. It is a native of South America. The specimen is in Mr. Hope's collection.

EPHIALTES MANIFESTATOR.

PLATE XXXII. Fig. 1.

Grav. Pimpla manifestator, *Fabr. Syst. Piez.* Ichneumon manifestator, *Linn. Marsham in Linn. Trans.* III. 23, Pl. 4, fig. 1–5.

THE subgenus ephialtes of Gravenhorst is characterised by a long abdomen, which is generally tuberculated, the anterior segments longer than broad, those at the apex with a longitudinal groove on the underside in the females; ovipositor long. The species above named is from eleven to fifteen lines in length, the female being largest. Body black, palpi and labrum ferruginous, thorax sometimes with a ferruginous spot at the base of the wings, the latter light smoke colour; legs long and rather slender, fulvous or rufous, the posterior tarsi and tibiæ, and sometimes the knees, fuscous. Ovipositor longer than the body, the tube chestnut red.

Perhaps the largest of the European Ichneumonidæ, and met with occasionally in most parts of Britain.

STEPHANUS CORONATUS.

PLATE XXXII. Fig. 2.

Jurine's Hymenop. Pl. 4, genus 4.

IN this group the head approaches to a globular form, the mandibles terminate in an entire or slightly notched point; the thorax is narrowed and elongated in front, and the abdomen appears almost sessile. The antennæ are long and slender, consisting of 32 joints. The species named *coronatus* is black, the abdomen dark red; legs likewise red, the tarsi and and anterior tibiæ pale. The insect is usually found, according to Jurine, on dry wood, and, when it flies, the abdomen forms a right angle with the thorax.

PELICINUS POLITURATOR.

PLATE XXXII. Fig. 3.

Drury's Exotic Ins. Vol. II. Pl. 40, fig. 4.

THIS generic group is at once known by the singular appearance of the abdomen, which is very long, nearly filiform, arched, and inserted in the thorax a little above the origin of the posterior legs. The hinder legs are thickened, and the antennæ straight and extremely slender. The species above referred to is entirely black, the wings tinged with brownish yellow. It is a native of Jamaica. It is probable that the very long and slender abdomen serves, in these insects, the same purpose which a lengthened ovipositor does in others, enabling them to place

their eggs in the bottom of holes and fissures, in the bark of trees, &c. which they might not otherwise be capable of reaching.

Order VII.—Lepidoptera.

This order includes the well known tribes of butterflies, hawk-moths, and moths properly so called, all of which possess the common property of having the wings, which are four in number, covered with small scales or feather-like bodies. It is to this the name refers, being derived from λεπτις, a scale. No kind of insects are more dissimilar in their different stages of metamorphosis. When they issue from the egg they appear in the familiar form of caterpillars, these change into a chrysalis, from which the perfect butterfly is in due time produced. Unfortunately we do not yet possess a complete systematic arrangement and description of these insects, at least not one conformable to the most recent and approved method of classification. This is the case in particular with the nocturnal Lepidoptera or moths, many of which are still undescribed. Our native species, however, of which there are nearly 2000, have been well described by Stephens in his Illustrations of British Entomology, by Haworth in his Lepidoptera Britannica, and in several other works. Among the best works on exotic Lepidoptera may be mentioned Horsfield's Lepidoptera Javanica Boisduval's Species Général des Lepidoptères, (Paris,

1836), and Godart's elaborate articles in the Encyclopédie Méthodique.

It is not intended to enter into the general history of the Lepidopterous order in this place, because three volumes of our entomological series have already been occupied with it, and it is not desirable to encroach further on the space requisite for the elucidation of the orders we have not touched upon elsewhere. We have, however, added another volume relating to this order, comprehending the history of Exotic Moths and Hawk Moths, which will afford an opportunity of supplying what it may be further thought requisite to say on the subject.

Order VIII. — Strepsiptera.

This singular order, composed of a few minute parasitical species, was established by Kirby, and it corresponds to what has since been named Rhipiptera by Latreille, and Rhipidoptera by Lamarck. The insects are extremely anomalous, insomuch that Latreille, on examining one of them, exclaims, "animal prorsus singulare, animum excrucians!" It is difficult to trace their natural affinities, from the imperfect structure of the mouth, and a greater number must be examined with anatomical precision, before we can be certain with regard to the position they ought to occupy in the series. In the synoptical table on page 200, it is stated that they have two wings, and this character, in connection with the form

of the mouth, will be sufficient to distinguish them. But it has been recently shown, that two minute appendages, attached to the sides of the mesothorax, may be regarded as representing anterior wings; these have been named pseudelytra, or *prebalanciers*. The structure of the other parts will be well understood from the dissections on Pl. XXXIII. which we have taken the liberty to copy from Mr. Curtis' Brit. Ent. as they are the most satisfactory that have come under our observation. The head (E) is broad and sessile, with a triangular projection in the centre; eyes lateral, globose, and formed of few large facets; antennæ with more than one branch (F 1, and G); palpi (H) large and two-jointed. The prothorax and mesothorax (I and K) are very short, being narrower than the head; the mesothorax (D 6), on the contrary, is large and long, and produces a large scutellum (D*), which projects over the abdomen, the latter composed of 8 or 9 joints, and somewhat incurved at the extremity. In Stylops the anterior wings appear as represented at K 9. It is on account of their twisted appearance that the name Strepsiptera (from στρεψις and πτερον) has been applied. The hinder wings, or what may be regarded as the only wings, if we consider their function, are very ample, folded longitudinally like a fan, the nervures remarkably fine (L 10). The legs are short and compressed, without spines, the tarsi (which are four-jointed,) having each joint furnished with a pubescent membrane (K 8*), claws wanting.

Rossi was the first who observed one of these

singular insects, and he concluded that they belong to the hymenopterous order. This he was induced to do chiefly by the circumstance of their being parasitic, in the larva state, on the bodies of various kinds of bees and wasps (*Andrenidæ* and *Vespidæ*). The larva and pupa of Stylops are figured at *B* and *C*, Pl. XXXIII. They live between the abdominal segments of the bee, as represented in fig. A, *a b*. An interesting account of the discovery of an English species of this order will be found in Kirby's Monographia Apum Angliæ, II. 113, and a full description of the order, in his Memoir in the XI. volume of the Linnæan Transactions.

As at present known, the order may be regarded as comprehending four genera. These may be distinguished by the antennæ: *Halictophagus* has four branches in these organs, in all the rest only two exist. In *Xenos* the antennæ are inarticulate; in *Stylops* the outer branch is flattened and three-jointed, this is likewise the case with *Elenchus*, but the joints are very long and slender.

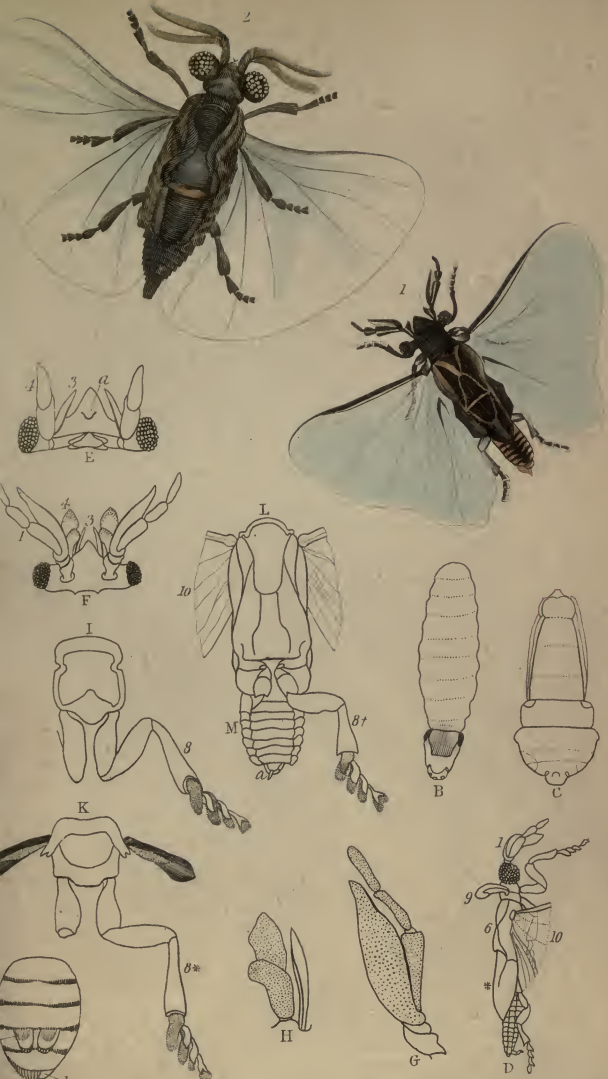
STYLOPS DALII.

PLATE XXXIII. Fig. 1.

Curtis' Brit. Ent. Vol. v. fol. 226.

BODY of a deep velvet black. Scutellum at the base, and abdomen at the sides, ochre yellow; wings white and iridescent; legs brownish. Length about a line and a half.

Obtained from *Andrena barbilabris* by Mr. Dale, after whom the insect is named.



1. *Stylops Dalii*. 2. *Xenos Peckii*.

Lizars a...

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XENOS PECKII.

PLATE XXXIII. Fig. 2.

Linn. Trans. Vol. xi. Pl. 8, fig. 8.

BODY brownish black; antennæ pale fuscous, almost diaphanous, sprinkled with minute white points. Wings ashy white, the anterior margin and nervures deep black, legs dull cinereous, tarsi dusky, extremity of the abdomen pale reddish. Length $1\frac{1}{2}$ lines.

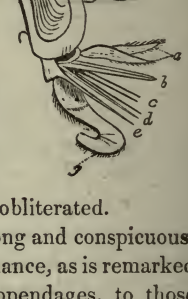
Larva and pupa found in *Polistes fucata*, an American insect.

ORDER IX.—DIPTERA.

THIS extensive order admits of a very brief and precise definition. The possession of only a pair of membranous wings, and a mouth formed for sucking, affords obvious characters for distinguishing it from all others. It is to the former peculiarity that the name refers, being derived from δις, *twice*, with the usual addition. Another marked singularity is to be found in the presence of two clubbed moveable bodies, termed balancers or halteres, projecting from each side of the thorax, and placed a little behind the wings.

The sucker attached to the mouth is composed of several slender pieces, from two to six in number, which are enclosed in, or rest upon, a fleshy proboscis or sheath, which gives support to them when employed, and also serves to pierce the cuticle of plants or animals, on the juice of which the insects live. When these pieces are six in number, they

are found to correspond in position and function, however different they may be in form, to the parts of the mouth in mandibulated insects, and much ingenuity has been exercised by entomologists in tracing this connexion. All these parts are fully developed in the mouth of *Tabanus*, and will be seen by the annexed figure, in which *a* represents the palpi, *b* the labrum, *c* the mandibles, *d* the maxillæ, *e* the tongue, and *g* the labium. The latter is usually very large and fleshy. Many of the parts just mentioned, however, disappear in certain dipterous tribes, and in some (*Œstridæ*,) all of them are completely obliterated.



The antennæ are sometimes long and conspicuous, bearing no inconsiderable resemblance, as is remarked by Latreille, both in form and appendages, to those of the nocturnal Lepidoptera. In an extensive section of the order, again, they are very short, composed of only two or three joints, the terminal one of which is commonly spindle-shaped, lenticular, or prismatic, with a simple or plumose bristle springing from its upper side.

The eyes are lateral, commonly large, those of the males being much the largest, and frequently meeting, or nearly so, on the crown of the head. The facets are sometimes larger on the upper than on the under side of the eye. They are occasionally variegated with bands of brilliant colours. When

ocelli are present, which is very frequently the case, they are usually three in number, and placed on the vertex.

The mesothorax is the segment of the anterior part of the body most developed in these insects, and it is so to such an extent as to leave but little space for the others, the prothorax being, in some cases, almost evanescent. The wings are somewhat long, and in general rather narrow, commonly clear and transparent, with simple nervures disappearing before reaching the apex, and crossed by a few transverse ones, the neuration being greatly more simple than in the hymenoptera. At the base of the wing, we very frequently find two rounded membranous scales applied with their faces to each other, which are named wing-scales, alulets, or winglets. They are sometimes of considerable size, and doubtless aid the movements of the wings materially in the act of flying. The use of the halteres, which have been already alluded to as two slender clubbed bodies placed behind the wings, can scarcely be said to be accurately known, but it is conjectured that they assist in giving a proper poise to the body in flight. Some have likewise supposed them to be connected with the function of respiration. They are often of a pale colour, and, when the winglets are large, partially covered by these appendages.

The abdomen is attached to the thorax only by a small portion of its transverse diameter; it is often long and narrow, sometimes oval or nearly round, varying in the number of its segments from five to

nine. In the females it frequently terminates in a tubular ovipositor, the joints of which are retractile within each other. The legs are generally long and slender, the articulations of the tarsi always five in number. The terminal joint, or that which bears the claws, is often provided with two or three membranous lobes, by the aid of which the fly is enabled to walk on glass and other smooth surfaces against gravity. This it was long supposed to do by the pressure of the atmosphere, the lobes in question acting as suckers and forming a vacuum. It has been recently conjectured, however, in opposition to this view, that it is accomplished by means of a glutinous secretion.

The larvæ of dipterous insects are in some respects even more peculiar than the mature fly. They are generally of a conical shape, the head being the narrowest part, and in all cases destitute of feet. The head is small, retractile, and variable in form even in the same individual,—that is to say, it is composed of a comparative soft fleshy substance which the insect can modify in shape at pleasure, to answer its various purposes. The colour is generally pale, but sometimes it is dark, and even bright red. The stigmata, in the species not aquatic, are most commonly placed in a cavity in the hinder segment of the body, which is capable of closing over them, so as to preserve them from being closed up by the fluid and putrid substances among which the larvæ often live. The breathing apparatus of the aquatic larvæ is often very singular, consisting of appendages of various

kinds attached to the tail. Those of the chameleon fly, the rat-tailed worm, and many of the common gnats, exhibit beautiful examples of ingenious natural mechanism. It is to the larvæ of Diptera that we apply the common term maggots or mawks; sometimes also they are termed grubs, but that appellation should be confined, for the sake of distinction, to the larvæ of the Coleoptera. They are often very destructive to corn and meadow grasses by eating the roots, and many of them, as is well known, rapidly consume animal substances, both in a dead and living state. The larvæ of the flesh-flies, in particular, (*Sarcophaga*, and certain species of *Musca*,) infest living sheep, and frequently prove fatal to them.

In the greater number of instances, the larva is changed into a pupa without shedding the skin; the latter merely hardens, changes its form somewhat by contracting, and thus becomes a case for the enclosed insect. Sometimes, however, the skin is cast off, and even a kind of cocoon formed; and the nymph occasionally retains the power of locomotion. This takes place only with such kinds as are aquatic.

This order is a most extensive one,—indeed there is every reason to believe that it falls very little short of the Coleoptera in this respect,—and, if we regard the number of individuals belonging to many of the species, they will be found greatly to exceed all others. Clouds of musquitoes are common in Northern Lapland, and in other countries, so dense and extensive as to intercept the rays of the sun; and, when we consider the small size of these insects,

it is obvious that the number necessary to do this must be astonishingly great. About 1700 have been named as belonging to this country; and it is probable that they will ultimately be found not to fall short of 2000.

Allusion has been already made to the injuries they commit, in the larva state, both to our domestic animals and to agricultural produce; but the purposes to which they are subservient in the economy of nature, are highly important and beneficial. Many of the smaller birds, as well as some other of the higher animals, depend upon them almost exclusively for food, and they are the most efficient instruments employed by nature in removing both animal and vegetable substances when rendered offensive and unwholesome to other animals by decomposition.

The most successful of the more recent investigators of this order are German and French Entomologists, particularly Meigen, Fallen, Wiedeman, Macquart, and Robineau Desvoidy. The following is Macquart's arrangement, slightly modified, for which we are indebted to Mr. Westwood's useful text-book:*

SECTION I. (*Ovipara* or *Larvipora*; DIPTERA, Leach.)—Head distinct from the thorax; sucker enclosed in a labial canal; claws of the tarsi simple, or with one tooth; the transformation to the pupa state not taking place within the body of the parent.

Division I. (NEMOCERA.)—Antennæ having six or more distinct joints; palpi with four or five joints.

* Page 420.

Ctenophora pectinicornis. 2. Tabanus tropicus. 3. Diopsis Ichneumonia.

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Fam. 1. (*Culicidæ.*)—Sucker with six lancets.

Fam. 2. (*Tipulidæ.*)—Sucker with two lancets.

Division II. (Brachocera.)—Antennæ having three distinct joints; palpi with one or two joints.

Subdivision I. (*Hexachæta.*)—Sucker with six lancets.

Fam. *Tabanidæ.*

Subdivision II. (*Tetrachæta.*)—Sucker with four lancets.

A. (Fam. *Cœnomyidæ*, *Beridæ*, *Stratiomydæ.*)

B. (Fam. *Mydasidæ*, *Asilidæ*, *Hybotidæ*, *Empidæ*, *Henopidæ*, *Nemestrinidæ*, *Bombyliidæ*, *Anthracidæ.*

C. (Fam. *Therevidæ*, *Leptidæ*, *Dolichopidæ*, *Syrphidæ.*

Subdivision III. (*Dichæta.*)—Sucker with two lancets, containing *Œstrus*, *Conops*, *Musca*, &c. &c., with numerous divisions and subdivisions.

Section II. (*Pupipara;* Homaloptera, Leach.)—Head immersed in the front of the thorax; sucker enclosed in two valves; claws with many teeth. The transformation to the pupa state undergone in the body of the parent fly.

Fam. 1. (*Hippoboscidæ.*)—Head frontal.

Fam. 2. (*Nycteribiidæ.*)—Head dorsal.

Of the few examples, native and exotic, selected to illustrate the general appearance of the insects of this order, we shall first refer to

CTENOPHORA PECTINICORNIS.

Plate XXXIV. Fig. 1.

Meigen, Curtis. Tipula pectinicornis, *Linn.* Tip. nigro-crocea, *De Geer.* Tip. variegata, *Fabr.* Tip. splendor. *Harris.*

In this genus the antennæ are beautifully pectinated in the male, but simple in the female. It contains seven or eight British species, most of which are among the most ornamented of all the Tipulidæ. The larvæ appear to inhabit decayed trees. The species figured occurs not unfrequently in most parts

of the country. The upper parts of the head, thorax, and abdomen are black, but the sides of a deep ochre or orange colour; wings smoke brown, the stigma dark; legs ochreous, the tarsi dusky.

TABANUS TROPICUS.

PLATE XXXIV. Fig. 2.

Linn. Panzer, &c.

THIS exemplifies the well-known tribe of horse-flies, which are so troublesome in warm weather, by fixing on these animals, and sucking their blood. This species is not one of the most common, but it occurs now and then throughout the country. The antennæ are ferruginous, dusky at the apex; eyes green, with three transverse rays of purple; thorax shining dark brown, with indistinct grey lines on the back; abdomen black, the first four segments widely fulvous at the sides, and the segments margined with the same colour behind; belly fulvous, dusky behind; tibiæ ferruginous, the anterior brown before the middle, the others generally somewhat dusky at the apex; tarsi black.

DIOPSIS ICHNEUMONEA.

PLATE XXXIV. Fig. 3.

Donovan's Indian Insects.

THIS group presents the remarkable singularity of having the eyes placed on long footstalks, whence the species are sometimes called telescopic flies. The antennæ are inserted on these lateral elongations. The abdomen is narrowed at the base some-

J.Westwood del.t

Lizars.sc

1.Asilus abdominalis. New S.Wales
2.Acanthomera immanis Brazil.

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thing like that of an ichneumon, and the thorax is armed with two spines. All of them are exotic, and but a small number are known. The individual figured is from Bengal. It is of small size, not exceeding four lines, (the figure being very much magnified,) the head, legs, and base of the abdomen yellow; the apex of the latter blue-black. The thorax is likewise of that colour, with a few white dots behind. The apex of the wing with a brownish black spot.

ASILUS (BLEPHAROTES, *West*) ABDOMINALIS.

PLATE XXXV. Fig. 1.

THIS represents a splendid insect belonging to the family Asilidæ, but differing from all the species of that family in the broad flattened abdomen and in the structure of the intermediate tarsi. These peculiarities have led Mr. Westwood to propose a new subgeneric name for its reception.

This insect is of an obscure brownish-black, with grey hairs; the nose is fringed with long fulvous hairs; the basal segment of the abdomen is thickly clothed with grey hairs, the four following segments smooth, shining, and of a rich green colour, with the posterior margin whitish, the sides of these segments are furnished with thick brushes of brown hair, those of the posterior segments being more mixed with buff hairs; the terminal segment is corneous, and armed with two curved horny appendages; the legs are robust and black; the intermediate tibiæ are short and clavate, with several

strong spines at the tip placed at right angles; the basal joint of the tarsi in these legs is singularly dilated at its internal base into a strong horny and toothed plate; the posterior tibiæ are clothed with fulvous hairs; the wings are pale brown, the basal lobe large and nearly black, the apical half of the wing brown with the nerves margined, especially at the hinder margin of the wing, with whitish; the third and fourth segments of the abdomen are furnished with a pair of tufts of black hairs; there is also a pair of more minute tufts on the fifth segment; halteres black.

Inhabits New South Wales. In the collection of the Rev. F. W. Hope.

"I have only seen," says Mr. Westwood, who furnished the drawing of this insect, "males of this curious species. I possess another still larger species of Asilus from New Holland, agreeing with the preceding in the broad and flattened abdomen with lateral tufts, and which is evidently the Asilus Coriareus of Weidemann, (Auss. Zweifl. Ins. 2, p. 644,) although the description of that author being derived from a solitary and mutilated specimen is necessarily incomplete. Of this species I have only seen females; and I have but little doubt that the insect here figured will ultimately prove to be the males of Weidemann's insect, notwithstanding the great diversity in their colours and general appearance. Both also agree in the peculiar direction of the subapical nerves of the wings."

ACANTHOMERA IMMANIS.

PLATE XXXV. Fig. 2.

THIS represents one of the most gigantic Dipterous insects hitherto discovered, and which appears to be the Acanthomera Immanis of Weidemann, (Auss. Zweifl. Ins. 2. app. p. 623,) although the description of the author is very incomplete, the only specimen which he had seen being in a very mutilated state. The specimen here figured is nearly two inches long and three inches in the expanse of the wings. It is a female, which sex differs from the males in the simple posterior femora, thus shewing the impropriety of the generic name which is derived from the toothed posterior thighs of the males alone, (which only were known to Weidemann when he established the genus.) The minute silvery dots, arranged in curved series on the second, third, and fourth abdominal segments, are very peculiar. The specimen here figured is in the collection of the Entomological Club and was presented by G. S. Bowerbank, Esq. It is from Brazil.

We have now completed our proposed review of all the orders of the Ptilota or winged insects. The three last orders indicated in the synoptical table, (page 200) include such genera as Pulex, Lepisma, Pediculus, Ricinus, and a few others of a similar nature, the general history of which forms a somewhat distinct department of the subject, not of very general interest, and which it is no part of our plan to enter into at present.

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